2.0

Summary of Activities

Air Monitoring Data and Evaluation of Health Concerns in Areas of Northeast Tri-County

April 1994

Washington State Department of Health

Environmental Health Programs

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
OFFICE OF TOXIC SUBSTANCES
Airdustrial Center, Building 4 • P.O. Box 47825 • Olympia, Washington 98504-7825

EPA – REGION 10
RECEIVED
APR 28 1994
WATER DIVISION
SURFACE WATER BRANCH

April 26, 1994

Lee Daneker
US EPA
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Dear Mr. Daneker:

Enclosed is a copy of the report, "Summary of Activities - Air Monitoring Data and Evaluation of Health Concerns in Areas of Northeast Tri-County," dated April 1994.

As a reminder, a public meeting to review this report is scheduled for Monday, May 9, 1994, at 7 p.m. in the gymnasium of the Northport High School.

If you have any questions, please contact me at the Office of Toxic Substances, P.O. Box 47825, Olympia, Washington 98504-7825 or at (206) 586-8734.

Sincerely,

FOR DH

David McBride, Toxicologist
Environmental Health Assessment Section

Enclosure

Summary of Activities

Air Monitoring Data and Evaluation of Health Concerns in Areas of Northeast Tri-County

April 1994

Washington State Department of Health

Prepared by:
Environmental Health Programs
Office of Toxic Substances
P.O. Box 47825
Olympia, Washington 98504-7825

In coordination with:

Department of Ecology
Air Quality Programs
P.O. Box 47600
Olympia, Washington 98504-7600
(206) 407-6800
(509) 456-6180

Contact person:
David McBride, Toxicologist
Office of Toxic Substances
(206) 586-8734

DOH Contributors to This Report:

Harriet Ammann, Ph.D., D.A.B.T.
Senior Toxicologist, Environmental Epidemiology and Toxicology Section

Kim Field, RN
Public Health Advisor, Community and Family Health Program

Aileen Haag,
Support Staff, Environmental Health Assessment Section

Denise LaFlamme, M.S.
Toxicologist, Environmental Health Assessment Section

Koenraad Mariën, Ph.D.
Toxicologist, Environmental Epidemiology and Toxicology Section

Dave McBride, M.S.
Project Manager, Toxicologist, Environmental Health Assessment Section

David Nash, M.S.
Public Health Advisor, Environmental Health Assessment Section

Glen Patrick
Public Health Advisor, Environmental Health Assessment Section

Juliet VanEenwyk, Ph.D.
Epidemiologist, Office of Epidemiology

Jim O. White
Section Head, Environmental Health Assessment Section

Special Acknowledgments to the Following Ecology Staff:

Engineering and Technical Services Section

Eastern Regional Air Quality Staff

Information and Data Services Section

Page # Contents

Executive Summary
Department of Health
Office of Toxic Substances

In July 1992, the Washington State Department of Health (DOH) proposed activities to be undertaken in response to community health concerns in the northeast tri-county area. These include concerns about: cancer rates; rates of inflammatory bowel disease; thyroid disease; peripheral neuropathies; possible exposure to environmental contaminants; exposure to lead and other heavy metals; air pollution; and elevated levels of manganese. Three status reports have been written to date by DOH to address theses concerns. Each report describes progress on eleven activities which were outlined in the initial report. In an on going effort to address these concerns, DOH has completed a fourth status report. This report describes progress on the activities since August 1993. A summary of the report follows.

Compare the rates of cancer mortality in Stevens County and Northport to rates for Washington State and the United States.

DOH compared the expected number of cancer deaths in the Northport area to the number reported by community members. Based on this analysis, DOH concluded that there have not been an excessive number of cancer deaths in the Northport area. DOH is in the process of looking at mortality in the Northport zip code, using 1990 census data and Washington State mortality data.

Compare the rates of hospitalizations for ulcerative colitis and Crohn's disease for Stevens County and Northport to rates of other counties.

Age-adjusted hospitalization rates from 1988 to 1991 indicate significantly higher rates of hospitalization for inflammatory bowel disease (IBD) in Stevens County than in Washington as a whole. Hospitalization rates for IBD in Okanogan, Pend Oreille, and Ferry Counties are also significantly higher than the state rate. These conclusions are tempered by the fact that the validity of using the hospitalization data set to compare counties has not been assessed. DOH is evaluating the validity of using the hospitalization data set.

Follow-up on unconfirmed cases of ulcerative colitis and Crohn's disease.

Rates of ulcerative colitis and Crohn's disease in the Northport area are higher than expected. DOH is currently unable to discern the cause of the elevated rates. If the cause is environmental, the most likely exposure may be to one of the many metals found in the area. However, this hypothesis is conjecture based on the abundance of metals in the region and the fact that excess ingestion of several metals causes gastrointestinal symptoms. DOH will continue to suggest research projects to universities and others which may help to identify the causes of colitis and Crohn's disease in the Northport area.

Follow-up on thyroid cases.

Follow-up on thyroid cases revealed prevalence rates of thyroidectomy and pre-existing hypo- and hyper-thyroidism in the Northport area to be comparable to rates for these conditions in several comparison groups. The dates of diagnosis and age ranges of those with goiter and hypothyroidism indicate that these conditions reflect historical iodine deficiencies rather than current exposure to goitrogens.

Follow-up on selected neuropathies to ascertain possible exposure to environmental contaminants.

This activity was completed before the April 1993 report and there was no additional work on this activity during this reporting period. The following is a summary of this activity from the April 1993 report.

Because the association of peripheral neuropathies with heavy metal exposure, especially arsenic, DOH discussed testing of private well water in Northport with Northeast Tri-county Health District (NETCHD). The health district reported that new wells are routinely tested for lead and arsenic. Since neither lead nor arsenic have been found in any of these wells and since the program to test new wells will continue, it was decided that additional testing was not necessary.

Conduct a literature review of goitrogens in water.

This activity was completed before the November 1992 report and there was no additional work on this activity during this reporting period.

After reviewing the literature on goitrogens in food and water, DOH has concluded that cobalt may be the most likely exposure. Cobalt interferes with iodine uptake in the thyroid. Epidemiologic studies suggest increased incidence of goiters in regions with relatively high levels of cobalt in water and soil.

The Department of Natural Resources (DNR) lists cobalt as a commodity from the Deep Lake area. Additionally, cobalt is usually found with copper. DNR lists copper as a mining commodity from two mines in the area. At least three citizens have reported elevated levels of copper in biological samples. It should be noted that medical records of these individuals have not been obtained to: 1) rule out the presence of genetically inherited inborn errors of copper metabolism and 2) verify the presence of elevated levels of copper.

Review a list of suspected pollutants for links with reported disease.

At the August meeting, several citizens expressed concern about exposure to sulfur-containing gas which is leaked when molten sulfur is transferred from barges to trucks just over the Canadian border. A representative from Cominco commented that the company was aware of the problem and was pursuing methods to reduce leakage.

Since airborne sulfur compounds originating from this site are not monitored, DOH is unable to provide an assessment of possible health effects. However, since gaseous products from molten sulfur are likely to contain sulfur dioxide (SO_2), an SO_2 focus sheet developed by Ecology is included with this report.

Appendix D, Lake Roosevelt Slag data, has been included as a follow-up related to citizen reports at the May 1992 meeting about a black, glass-like substance found on the beaches of the Columbia river.

Nominate Northport as one of the sites targeted in the lead soil sampling project.

In May 1993, DOH and NETCHD conducted environmental lead testing in the Northport and Onion Creek Elementary Schools. Classroom dust, playground surface soil, paint, and drinking water were sampled. Levels of lead which exceed Housing and Urban Development's (HUD) recommended level were detected at the Onion Creek Preschool indicating the presence of lead-based paint. DOH recommends that the school districts monitor paint to insure that it is not peeling or chipping and NETCHD will work with schools as an information resource.

Several water samples from the Northport Elementary School had lead levels slightly above the action level recommended by EPA. The NETCHD recommended to the Northport School District that: 1) faucets and fountains used for drinking be run for ten minutes at the start of each day and again at noon; 2) students and staff be instructed to allow the water to run a few seconds before drinking; faucets in the kitchen need to be run in the morning only; 3) faucets and drinking fountains suspected of having lead problems be replaced.

EPA contracted for a site inspection of the abandoned Leroi Smelter Company site in Northport. A summary of that report is included as Appendix E. DOH will review the report for its health significance. EPA is considering further sampling for heavy metals in the area.

Blood lead monitoring in children residing in Northport and vicinity.

Based on a recommendation of DOH, NETCHD ran a blood screening clinic in September 1993. This was a follow-up to the blood lead screening which took place in December 1992. Since only 7 of the children who participated in the screening were between the ages of 1 and 3, NETCHD and DOH believe that the issue of lead poisoning in children in Northport has not been fully addressed. NETCHD will continue to provide the Northport community with information on the importance of lead testing. Brochures will be available at the clinics, Northport School District, and other information offices. Lead screening for children under 3 will be made available on an individual basis as requested by parents. DOH supports these efforts and will work with NETCHD in the awareness program.

Health Evaluation of Particulate Air Samples.

Particulate air sampling indicated that arsenic and cadmium were at levels that required health analysis. Lead, while not exceeding the NAAQS, continues to be of concern.

Cadmium is toxic to the kidney and arsenic has been shown in some epidemiological studies to cause a small increase in lung cancer rates in adult populations exposed to smelter emissions. At present DOH does not have information on soil concentrations, but because of deposition of contaminated of air particles, DOH advises minimization of exposure to these heavy metals from soil. Home grown fruits and vegetables should be washed to remove dust. Hands should be washed before eating. Toddlers should not play on bare soil.

Because smoking can double the exposure to cadmium, DOH advises citizens not smoke.

Ecology conducted air sampling for various metals in the Northport area. Their executive summary follows immediately.

Obtain manganese blood and urine data from physicians and assess the need for additional testing.

In July of 1993 Ecology, NETCHD and DOH developed a work plan to address the community's concern about exposure to manganese in the Kettle Falls area. DOH's role is to investigate potential health effects from possible environmental exposure to manganese and to review medical records to determine whether manganese toxicity is occurring.

Biological evidence has shown that high levels of manganese exposure can cause adverse human health effects. In fact, that high levels of manganese in the air and dust have been associated with adverse health effects has been documented in numerous occupational studies. The principal concern associated with manganese exposure is its neurotoxic effects on the brain. Very few studies have been conducted to investigate health effects associated with manganese and drinking water.

Given the lack of adequate environmental data from both air and water sources, together with the lack of apparent clinical findings suggesting manganese toxicity from the reviewed medical reports, DOH is unable to conclude at this time a direct cause and effect relationship associated with manganese exposure in the Kettle Falls area. This is not to say that adverse health effects are not resulting from exposure to manganese from this area. Given the lack of adequate environmental data, DOH will evaluate additional environmental sampling once it becomes available to better characterize possible exposure to manganese and make appropriate recommendations based on these findings.

Future Activities

- DOH, NETCHD, and Ecology will continue to work with community residents to address their health concerns.

- To further address residents' concerns about cancer, DOH is currently reviewing the 1990 census file of the Northport zip code to determine cancer mortality rates. Once this is completed, DOH will compare cancer mortality rates with Washington State to determine whether differences exist. This analysis will be presented in an upcoming report.

- DOH is beginning a systemic evaluation of hospitalization data to determine its validity in assessing IBD by county comparisons. This information will be reassessed when the evaluation is complete. If it is found that the use of hospitalization is valid, DOH will explore possible research options with universities and others aimed at identifying possible environmental causes of UC and CD disease in the Northport area.

- NETCHD plans to continue to provide the Northport community with information on the importance of lead testing. NETCHD is working with local school districts to provide information on reducing exposure to environmental lead. Lead screening will be made available to children under 3 by the health district.

- DOH recommends that further monitoring of blood of children under 3 be conducted to fully address the lead poisoning issue in the Northport area. DOH recommends that an active education effort in the community be undertaken to raise community awareness regarding the danger of lead exposure to small children. DOH supports the efforts of NETCHD and will work with them in the awareness program.

- DOH will continue to analyze and evaluate air monitoring data as it becomes available from Ecology. In addition to analysis of air sampling, DOH will work with community members, Ecology, and EPA to evaluate any additional soil or water samples collected from the Northport and Kettle Falls area and provide community members with those findings.

EXECUTIVE SUMMARY
DEPARTMENT OF ECOLOGY
AIR QUALITY PROGRAM

INTRODUCTION

In the winter of 1992, the Washington State Department of Ecology (Ecology), at the request of the Department of Health, initiated a study of air quality at Northport to help identify the cause of health problems reported by local residents.

Ecology's air monitoring study was conducted in two phases. Phase I was conducted from December 15, 1992 through February 13, 1993, primarily to identify maximum lead concentrations in the Northport and Kettle Falls area and provide this information to the Department of Health for its blood lead study. Phase II was conducted form August 10 through October 30, 1993, to determine the concentration of lead, arsenic, and other metal pollutants in the air in the Northport and Kettle Falls area.

HOW THE STUDY WAS CONDUCTED

Five air monitoring samplers were installed during the first round--four in Northport and one Kettle Falls. Approximately 100 samples of particulate matter (dust and soot particles in the air) were collected and analyzed for concentration of lead, arsenic, and particulate matter itself. Total suspended particulate (TSP includes all sizes of airborne particles) as well as particles smaller than 10 thousandths of a meter in diameter (PM_{10}) were measured. (Particulates were selected because they are thought to be the most *probable* pollutant and because studying particulate matter can lead to information about the presence of other pollutants in the air.)

During the second round, seven monitoring sites were chosen, first in areas where we suspected high metals concentrations in the Northport and Kettle Falls area, and second, in a north-south pattern of monitoring sites from Trail, B.C. to Kettle Falls. These were chosen to evaluate the concentrations of metals coming from the Cominco smelter in Trail, B.C. Some residents felt that the smelter was a likely source of local pollution.

The particulate filters were scanned for 31 potentially toxic metals. Ecology selected seven of those metals to analyze, based on which metals would likely come from a smelting operation, local mining operations and other potential local sources. Cadmium, zinc, antimony, lead, copper, arsenic, and manganese were the metals selected. The first four listed would be consistent with a smelting operation.

Finally, computer modeling was conducted to better understand the probable sources of pollutants and their dispersion in the atmosphere.

What We Found By Monitoring

Particulates

- Neither the state TSP nor the PM_{10} standard were exceeded during the study period. Both standards are 150 micrograms per cubic meter for a 24-hour average. "Standards" are set by the federal and state government based on health effects and other factors. If the standard is exceeded, the pollution level is considered unsafe. The highest TSP level measured during Phase I was 56 micrograms per cubic meter. The highest PM_{10} value measured was 42 micrograms per cubic meter. During Phase II, the highest TSP value was 62 micrograms per cubic meter and the highest PM_{10} value was 64 micrograms per cubic meter on the same day. The average of the values of particulate (TSP and PM_{10}) for the study period was about 24 micrograms per cubic meter.

Lead

- Phase I data indicated no violations of the federal and state lead standards although the recorded lead concentrations were some of the highest in the state during that time. The federal lead standard is 1.5 micrograms per cubic meter for a three-month average. The highest average value measured was 0.92 micrograms per cubic meter at the Worthen site for the two months from mid-December 1992 to mid-February 1993. During Phase II, the third quarter average at one site was 0.14 micrograms per cubic meter. The levels of lead in Northport, compared to suburban areas of the state, are elevated--although, again, they did not exceed the federal, health-based, lead standards.

Arsenic

- No federal or state standard has been set for arsenic, but it did exceed what's called an "Acceptable Source Impact Level" (ASIL). ASILs are outdoor concentration values of various air pollutants used by Ecology as "screening" values. For example, if the air concentrations are equal to or less than the ASIL values, the "risk" to the exposed population is considered negligible. If the levels are higher than the ASIL value, additional analysis is needed to evaluate the risk.

- Arsenic's exceedence of the ASIL is somewhat misleading because the ASIL values are **yearly** averages whereas the Phase II sampling period lasted only 42 days. Normally, daily maximum pollutant concentrations tend to be much higher than quarterly average concentrations. For example, the maximum 24 hour arsenic value measured at Waneta is 0.1164 micrograms per cubic meter. If the data from the Waneta site are averaged over the 42 days of the Phase II study, this average value drops to 0.0800 micrograms per cubic meter, supporting the notion that quarterly maximum averages tend to be lower than daily maximum averages. There is a strong likelihood that had Phase II lasted a year, the resulting yearly, arsenic concentration would be much lower still--perhaps much closer to the ASIL values.

- Ecology routinely obtains State Health Department review of health impacts form new sources of air pollution which exceed the ASIL.

Cadmium

- Waneta was also the site of the highest cadmium level measured during Phase II. The 24-hour maximum value was 0.0474. If the dates are averaged over a 42 day period. This average value drops to 0.0800 micrograms per cubic meter.

.0076

Copper, Zinc, Antimony, and Manganese

- As we stated, there is a state and federal standard for lead, but levels of the other metals are compared to the Acceptable Source Impact Level (ASIL) as a screening method. Copper, zinc, antimony, and manganese all had concentrations much lower than the ASIL.

COMPUTER MODELING

After Phase I, it was recommended that further air monitoring be conducted along with computer modeling. Ecology conducted a computer air quality monitoring simulation of the study area to "predict," or gain better insight into where pollutants were most likely to be deposited and from where they are likely to come.

Two different computer models were used. One calculates wind speeds and directions in mountainous terrain based on information provided by local weather stations. The other took that information plus the concentration of pollutants emitted from local sources to calculate the concentrations of pollutants in the area around and downwind of the sources. The modeling was done using the data from the day with the highest levels of pollutants.

The model confirmed the high variability of wind speed and direction in the study area, especially along the valley, from hour to hour and place to place. Wind speed and direction can vary with height as well. Nevertheless, the model confirmed the monitoring data results in predicting that winds and pollutants from the Cominco smelter can easily travel down the Columbia River Valley to produce moderately high pollutant concentrations in the study area.

CONCLUSIONS

No federal or state particulate standards were exceeded during the winter of 1992-93 or during the fall of 1993 when outdoor air sampling was done. Nevertheless, analysis of the seven metals chosen indicated that two of the metals, arsenic and cadmium, were recorded at relatively high levels. Lead levels were high when compared to monitoring levels in other parts of the state, but did not exceed the existing federal and state standards.

The significant quantities of lead, arsenic, and cadmium in the air in the Northport area suggest that a smelting process is a likely source of these metals.

FUTURE ACTIONS

- Ecology will continue PM_{10} particulate sampling at the Paparich site for one full year ending August 31, 1994. Lead, arsenic, zinc, and cadmium will be analyzed in order to gather a full year's data to better compare results to annual ASILs and determine any seasonal variations. This information will be presented to the Department of Health.

- Ecology will operate a weather station in Northport for a year, beginning in the summer of 1994, to get local wind speed, direction and air temperature data for an entire year. This will help refine the ongoing air quality computer modeling. Ecology will monitor and model the study area to better determine the relationship between the emission of the metals and local weather conditions. The modeling will be helpful when Ecology reviews future permit actions for Cominco Ltd. or any other new sources of air pollution in the area.

- When the Cominco permit is in the process of review, Ecology will participate in order to ensure that Washington State's air quality is protected. This is in keeping with the Memorandum of Understanding recently signed by British Columbia Environment, Washington State Department of Ecology, Northwest Air Pollution Authority, and the Greater Vancouver Regional District in British Columbia, The purpose of that agreement is to facilitate timely information sharing between the agencies. This includes prior-consultation on air permits if they have the potential for cross-border air quality impacts.

Activities Of Washington State Department Of Health In Relation To Proposals In The July 1992 Report

In July 1992, Washington State Department of Health (DOH) proposed activities to be undertaken in response to community health concerns. In November 1992, April 1993, and August 1993, DOH reported the activities related to and the status of each proposal. This report summarizes activities undertaken from August 1993 through March 1994, and presents conclusions and the status of each activity. The italicized text are the proposed DOH activities contained in the July 1992 report.

Epidemiologic Reviews

1. *Compare rates of cancer (particularly brain and colorectal cancers) mortality in Stevens County and Northport to rates for Washington State and the United States.*

Mortality From All Types Of Cancer

In the April 1993 report, DOH concluded that cancer mortality rates for all cancers and brain, colorectal and thyroid cancer in Stevens County are similar to those in Washington State. The same report stated that when population counts by zip codes became available from the United States Census Bureau, a cancer mortality rate for the Northport zip code would be calculated. DOH has recently received a copy of the 1990 census file and is in the process of looking at cancer mortality rates in Northport zip code.

At the public meeting in August 1993, several people expressed continued concern about cancer in the Northport area. In response to this concern, DOH estimated the expected number of cancer deaths in the Northport area. Based on 1989 and 1991 cancer mortality in Washington State and the United States, 1 to 2 deaths from cancer are expected in the Northport area each year. Over a 20 year period, approximately 28 or 30 deaths are expected, based on Washington State and United States data, respectively. These estimates are not significantly different from the 32 deaths reported in the citizens' reports, some of which may be outside the area of consideration. The calculations use 1990 census data for the incorporated area of Northport and estimate that an equal number of people with the same age and sex distribution live in the surrounding area. A more detailed description of the methodology used for these calculations and the limitations of the estimates are presented in Appendix A. It should be noted that in spite of the limitations of the estimates, DOH believes that the findings do not indicate excessive cancer mortality in the Northport area.

At the public meeting, several community members stated that neither Stevens County nor the Northport zip code adequately reflects the population of concern. Residents requested that DOH conduct a study of cancer in the Northport School District. Since cancer data are not available by school district, this request requires that a special survey be conducted.

Enrollment data from Northport High School indicate that 60% of the children live in the Northport zip code. If cancer rates in the Northport area are elevated compared to the rest of Washington State, the elevation will be evident when looking solely at the Northport zip code. By analogy, if cancer rates in all of the counties of the Northeast Tri-Counties Health District (NETCHD) were elevated, high cancer rates would be discerned if one chose to study one of the counties separately. DOH has decided not to conduct a special survey at this time.

CANCER RATE CONCLUSIONS

DOH has concluded that there have not been an excessive number of cancer deaths in the Northport area when compared to the rest of Washington State. DOH is in the process of looking at mortality rates in the Northport zip code using the 1990 census data. This analysis will be presented in an upcoming report.

2. ***Compare rates of hospitalizations for ulcerative colitis (UC) and Crohn's Disease (CD) for Stevens County and Northport to rates for selected control counties.***

CASES OF ULCERATIVE COLITIS AND CROHN'S DISEASE

As was noted at the public meeting in August 1993, the April and August reports of the preliminary analysis of hospital discharge data were in error. These reports stated that the preliminary analysis showed rates of hospitalization for UC and CD in Stevens County to be similar to those in Washington State. In fact, the preliminary analysis indicated that crude (i.e., not age-adjusted) rates of hospitalization for inflammatory bowel disease[1] (IBD) were significantly higher in Stevens County than in Washington State. The preliminary analysis included data from 1988 through 1990.

Since the August 1993 report, 1991 hospital discharge data became available and were incorporated into the analysis. Age-adjusted hospitalization rates for IBD are significantly higher in Stevens County than in Washington State as a whole. It is of interest that age-adjusted hospitalization rates in Okanogan, Pend Oreille, and Ferry Counties are also significantly higher than the state rate. All four of these counties are among the nine counties with the highest rates, with Stevens, Pend Oreille, and Ferry having the 7th, 5th and 2nd highest rates, respectively. The number of hospitalizations in the Northport zip code continues to be too small for meaningful analysis.

The validity of comparing counties to each other or to the state using hospitalization data has not been adequately assessed. There may be systematic biases which result in some counties having inflated or deflated rates compared to other counties. For example, counties with large military populations and military hospitals will have artificially low rates of hospitalization, since military hospitals are not included in the data set. Counties along the Oregon border may have higher

---

[1] ICD-9-CM codes 555 (regional enteritis, including Crohn's disease, colitis and ileitis) 556 (idiopathic proctocolitis) and 558.9 (other and unspecified non-infectious gastroenteritis and colitis).

rates, since the Oregon data are merged with the Washington data, but duplicates can not be eliminated. Counties in which a portion of the population is hospitalized in Idaho may have artificially low rates, since data from Idaho are not available.

DOH is beginning a systematic evaluation of the hospitalization data to ascertain the validity of using this data set for county specific comparisons. The hospitalization data reported above will be reassessed when the DOH evaluation is completed. If rates in all four counties of the northeast corner of Washington are high compared to the state as a whole, one would look for an environmental exposure that is found in the entire area rather than an exposure unique to Northport.

3. ***Follow-up on unconfirmed cases of ulcerative colitis (UC) and Crohn's Disease (CD): obtain medical records to confirm diagnosis and perform rate determination.***

In April 1993, DOH reported that of the 19 people originally believed to have inflammatory bowel disease, five people stated that they did not have inflammatory bowel disease. These five people did not provide medical records or complete questionnaires. Of the remaining 14 individuals, seven sets of records were received. Since April 1993, records for an additional three people have been received. The records for two of these people indicate intestinal disease other than UC or CD. For the third person, a sigmoidoscopy which is necessary for a diagnosis of UC or CD is pending. Since there have not been additional reports of UC or CD in the Northport area, the conclusions of the April and August 1993 reports have not changed.

Because the causes of UC and CD are unknown and because no unique or rare potential exposures have been identified in the Northport area, DOH is currently unable to discern the cause of UC and CD in Northport. DOH believes that because cases of UC and CD are continuing to arise and because there is a large array of potential exposures, Northport may offer a unique opportunity for discovering the cause of UC and CD. A letter was sent to Dr. Boyko, an internist at the Veteran's Administration Medical Center in Seattle and an Associate Professor of Medicine at the University of Washington, to obtain his perspective about the possibilities for research on UC and CD. A copy of the letter is included as Appendix B.

Dr. Boyko's initial response was that the number of cases of UC and CD in the Northport area is not statistically significantly different from the expected number of cases and that eight cases are not a sufficient number for research purposes. DOH's calculation of statistical significance indicates that the number of cases in the Northport area is statistically significantly greater than expected[2]. However, DOH concurs that it is difficult to do research with so few incident cases

---

[2] The expected number of cases ranges from 5 to 15 per 100,000 person-years (Calkins, BM and Mendelhoff, AI. Epidemiology of inflammatory bowel disease. *American Journal of Epidemiology, 8*:60-91, 1986). Eight cases were observed during 10,200 person-years (600 people per year for 17 years). Exact 95% confidence intervals for the 8 observed cases were calculated using probability values from the binomial distribution (SAS function PROBBNML, *SAS Language Guide for Personal Computers, Release 6.03 Edition*, p. 85). The lower confidence limit of 3 cases per 10,200 person-years is higher than the expected value of 0.5 to 1.5 per 10,200 (i.e., 5-15 per 100,000). Therefore, the 8 cases are statistically significantly higher than expected.

each year. Dr. Boyko suggests that DOH expand the case ascertainment area so that more cases will be included. He also thought that the proposal to look at prevalence of UC and CD in relation to soil type merited further exploration.

Dr. Davis, an Epidemiologist, who conducted the initial investigation into UC and CD in the Northport area, suggested an additional research option, which was to investigate whether IBD is a contributing cause of death in relation to occupational exposures. The feasibility and merit of pursuing various research options will be explored by DOH's Office of Epidemiology.

UC And CD Conclusions

Rates of UC and CD in the Northport area are higher than expected. DOH is currently unable to discern the cause of the elevated rates. If the cause is environmental, the most likely exposure may be to one of the many metals found in the area. However, the hypothesis is conjecture based on the abundance of metals in the region and the fact that excess ingestion of several metals may cause adverse gastrointestinal symptoms. DOH will continue to suggest research projects which may help identify the causes of UC and CD disease in the Northport area.

4. ***Follow-up on thyroid cases: obtain medical records to confirm diagnosis and perform rate determination.***

Thyroid Cases

Medical records were sought from 23 individuals who were reported at public meetings or in written reports from interested citizens to have thyroid disorders. Fourteen sets of medical records were received. Eight additional individuals were contacted by telephone and one individual could not be contacted. The following evaluation is based on the review of medical records, where available, and on self-report when telephone contact was made, but no medical records were received. The inclusion of the unconfirmed, self-reported thyroid disorders will increase the prevalence of selected diagnoses. However, where medical records were received, they corroborated the individual's self-report. Table 1 presents the number and characteristics of individuals with thyroid conditions.

Table 1: Summary of Reported Thyroid Disease in the Northport Area					
Primary Diagnosis	Number	Current Age Range	Years of Diagnoses[a]	Number with Medical Records	Number of Current Northport Area Residents
Goiter	5	63-87	1945-1976	4	3
Hyperthyroid	2	41-63	1968-1971	2	2
Hypothyroid	8	23-69	1964-1987	7	6
Hashimoto's	1	*	1978	1	1
Grave's	1	*	1990	0	0
Cancer	1	deceased	1945	0	0
Unknown	1			0	1
Total Thyroid	19			14	13
No Disorder	3			0	0
No Contact	1			0	0
TOTAL	23			14	13

[a] Year thyroid disorder first diagnosed.

* To protect confidentiality, age ranges are not given.

Thyroid disease was confirmed for 19 of the 23 individuals originally reported to have thyroid disease. In 14 cases, the diagnosis was confirmed by the medical record. Given the dates of diagnosis and age ranges of those with goiter and hypothyroidism, these conditions seem to be more reflective of historical iodine deficiencies than of current exposures.

In order to understand the meaning of the numbers reported in Table 1, rates of thyroid disease in the Northport area must be compared to background rates. Prevalence refers to the percent of people in a defined geographic area who have a particular disease or condition at a point in time. Incidence refers to the number of new cases of disease diagnosed in a given time period. Although incidence is usually the preferred way of measuring rates of disease, the medical literature generally reports prevalence rather than incidence rates of thyroid disease. Therefore, the assessment of thyroid disorders in the Northport area relies on a comparison of prevalence rates between Northport and other communities.

When assessing prevalence, only those individuals living in a given location at a particular time are included. Five individuals with thyroid disorders were not living in the Northport area at the time of case ascertainment. Therefore, they are not included in the assessment of prevalence.

The 1990 United States Census reports 308 residents in the incorporated area of Northport. Dr. Davis estimated that an equal number of people live in the surrounding area. Based on this estimate, there are about 600 people in Northport and the surrounding area. The 1990 Census reports 210 people ages 18 years or older living in incorporated Northport. If an equal number of adults live in the surrounding area, there would be 420 people age 18 and older in the Northport area. These population denominators are used in the calculation of prevalence rates.

Most of the prevalence rates reported in the medical literature are derived from examination of patients for thyroid disease. Since thyroid disease can be undiagnosed for a relatively long period of time, an active effort to find cases of thyroid disease through examination will result in higher rates than rates based on already-diagnosed disease. Since DOH did not examine those with no known thyroid disease, DOH is using reports of already-diagnosed thyroid disease. Therefore, the communities which can be compared to Northport are limited to those for which information on already-diagnosed thyroid disease is available.

One of the most complete population based studies of thyroid disease was undertaken in Tecumseh, Michigan from 1959 to 1960. Since both Tecumseh and Northport are areas of historic iodine deficiency, the Tecumseh data offer a reasonable comparison to Northport. Prevalence of thyroidectomy is a good indicator of thyroid disease, since it reflects procedures that were undertaken as part of routine medical care and is not affected by active examination for thyroid disease.

As Table 2 indicates, the prevalence rates for thyroidectomy, thyroidectomy due to goiter and thyroidectomy due to hyperthyroidism are similar in Northport and Tecumseh. The female to male ratios for thyroidectomy are similar in the two communities with a ratio of 5.5 to 1 in Tecumseh and 4 to 1 in Northport. At the time of surgery, those in Tecumseh were between 18 and 72 years old. This is comparable to an age range of 19 to 70 years in Northport. The majority of surgeries occurred in the 20 to 59 year old age range in both locations.

Table 2: Thyroidectomy in Tecumseh, Michigan and Northport, Washington

	Tecumseh	Northport
Thyroidectomy	0.95%	5/600 = 0.83%
Due to goiter	0.65%	3/600 = 0.50%
Due to hyperthyroid	0.27%	2/600 = 0.33%

A second study which reports on rates of pre-existing hypo- and hyper-thyroidism was conducted in Whickham, England from 1972 to 1974. The study surveyed a random sample of men and women 18 years old and older. Table 3 shows that the rates of both hyper- and hypothyroidism are similar in Whickham and Northport[3]. Dr. Hamilton, an endocrinologist at Pacific Medical Center, indicated that the prevalence of hypothyroidism is about 1%. The prevalence of hypothyroidism in Northport is similar to this value.

Table 3: Rates[b] of Hyper- and Hypothyroidism in Whickham, England and Northport, Washington

	Whickham	Northport
Hyperthyroidism	1.1% to 1.6%	4[c]/420 = 1.0%
Hypothyroidism	0.8% to 1.1%	4[d]/420 = 1.0% to 7[d]/420 = 1.7%

[b] The first rate in each category refers to confirmed cases only. The second rate includes confirmed and possible cases.

[c] Includes 1 case of Grave's Disease and one case with a primary diagnosis of goiter

[d] Includes 1 case of Hashimoto's Disease

THYROID CONCLUSIONS

Follow-up on thyroid cases revealed prevalence rates of thyroidectomy and pre-existing hypo- and hyper-thyroidism in the Northport area to be comparable to rates for these conditions in several comparison groups. The dates of diagnosis and age ranges of those with goiter and hyperthyroidism indicate that these conditions reflect historical iodine deficiencies rather than current exposure to goitrogens.

5. ***Follow-up on selected peripheral neuropathies to ascertain possible exposure to environmental contaminants.***

This activity was completed before the April 1993 report and there was no additional work on this activity during this reporting period. The following is a summary of this activity from the April 1993 report.

Because the association of peripheral neuropathies with heavy metal exposure, especially arsenic, DOH discussed testing of private well water Northport with NETCHD. The health district reported that new wells are routinely tested for lead and arsenic. Since neither lead nor arsenic have been found in any of these wells and since the program to test new wells will continue, it was decided that additional testing was not necessary.

[3] The 95% lower exact confidence interval based on the binomial distribution for the 1.7% hypothyroidism is 0.5%. Since this figure is lower than the expected value of 0.7% to 1.1%, the 1.7% is not statistically significantly higher than expected.

At the May 1992 public meeting, three individuals were reported to have similar symptoms of peripheral neuropathy. Staff from DOH were unable to contact one of the individuals. Testing results from two of the individuals do not indicate environmental exposures. In one case, symptoms were no longer present.

Unless requested by the individuals involved, DOH will not investigate these cases further.

Toxicological Review

6. ***Conduct literature review of goitrogens in water.***

This activity was completed before the November 1992 report and there was no additional work on this activity during this reporting period.

After reviewing the literature on goitrogens in food and water, DOH has concluded that cobalt may be the most likely exposure. Cobalt interferes with iodines uptake be the thyroid and epidemiologic studies suggest increased incidence of goiters in regions with relatively high levels of cobalt in water and soil.

The Department of Natural Resources (DNR) list cobalt as a commodity form the Deep Lake area. Additionally, cobalt is usually found with copper, and DOH suspects that the Northport area has naturally occurring high levels of copper in the environment. DNR lists copper as a mining commodity form two mines in the area. In addition, at least three citizens have reported elevated levels of copper in biological samples. It should be noted that medical records of these individuals have not been obtained to: 1) rule out the presence of genetically inherited inborn errors of copper metabolism and 2) verify the presence of elevated levels of copper.

7. ***Review list of suspected pollutants for links with reported disease.***

At the August 1993 meeting, several citizens expressed concern with molten sulfur, which is transferred from barges to trucks just over the border in Canada. The citizens reported that there was leakage during the transfer and they were concerned that the molten sulfur vaporized causing periodic exposure to sulfur-containing gases. A representative from Cominco commented that the company was aware of the problem and was pursuing methods to reduce leakage.

Since airborne sulfur compounds originating from this site are not monitored, DOH is unable to provide an assessment of the health effects at this time. However, since gaseous products from molten sulfur are likely to contain sulfur dioxide (SO_2), a SO_2 focus sheet developed by Ecology is included with this report as Appendix C.

One citizen, who could not stay for the entire meeting, asked to be contacted by DOH about the molten sulfur. The citizen inquired about developing a complaint line so that authorities could be notified about episodic exposures to noxious air. The citizen was referred to Ecology, the agency which monitors and regulates air quality. Ecology has provided moneys to establish a complaint lines at other sites.

It is DOH's understanding that a complaint line will not be established at this time. However, citizens are encouraged to call Grant Pfeifer at the Eastern and Central Region Office of Ecology's Air Program to register on-going complaints about air quality. Mr. Pfeifer can be reached at (509) 456-3284.

Except for the molten sulfur, there were no new possible contaminants which were brought to the attention of DOH during this reporting period.

Appendix D, Lake Roosevelt Slag data, has been included as a follow-up related to citizen reports at the May 1992 meeting about a black, glass-like substance found on the beaches of the Columbia River.

Air, Soil, and Biological Sampling

8. ***Nominate Northport as one of the sites targeted in the lead soil sampling project.***

In May 1993, DOH and NETCHD conducted environmental lead testing in the Northport and Onion Creek Elementary Schools. Classroom dust, playground surface soil, paint, and drinking water were sampled. Preliminary data indicate that all of the dust and surface soil samples were below action levels established for lead, indicating that dust and surface soil contamination is not problematic at these schools.

Lead-based paint was not detected at Northport or in the main school at Onion Creek. Levels of lead at the Onion Creek Preschool exceeded the Housing and Urban Development's (HUD) remediation levels indicating the presence of lead-based paint. Because there is no peeling paint at the present time, remediation is not necessary. However, DOH recommends that the schools monitor to assure the integrity of the paint. NETCHD will work with the schools as an information resource. If any maintenance of the building involving painting, sanding, scraping, or heat removal of paint is undertaken, adequate measures to prevent environmental exposures to lead must be taken.

Three of the water samples from the Northport Elementary School had lead levels slightly above the 15 micrograms per liter recommended action level established by the United States Environmental Protection Agency (EPA). NETCHD conducted follow-up water sampling on August 23, 1994. The follow-up testing indicated that lead levels dropped below the recommended action level after water was allowed to run.

The NETCHD recommended to the Northport School District the following:

"1. All faucets and fountains used for drinking should be run for about ten minutes at the start of each day and again at noon. Faucets in the kitchen need to be run in the morning only.

2. Students and staff should be instructed to allow the water to run for a few seconds before drinking.

3. At this time we suspect the problem may be in the fixtures. Tom Justus, DOH, is checking into faucets that will not contain lead. When this information is available, we recommend that the faucet and drinking fountain in the kindergarten and the faucet in the lunchroom be replaced and samples taken for analysis. If results from those tests indicate correction of the problem, you should consider replacement of other fixtures."

These recommendations are presently being followed. Northport School District has replaced the faucet fixtures, which is a likely source of the lead contamination.

In addition to the soil sampling conducted through DOH, EPA contracted for a site inspection of the abandoned Leroi Smelter Company site in Northport. A summary of that report is included as Appendix E. A full copy of the report is available upon request. DOH will review the report for its health significance.

9. *Blood-lead testing in children residing in Northport and vicinity.*

The April 1993 report summarized the results of a lead screening program that was undertaken in December 1992. Blood lead levels reflect only relatively recent exposures to lead. If children's exposures to lead are from playing in lead-contaminated soil during the summer, blood lead levels will be highest towards the end of the summer and into early fall. Due to the timing of this lead screening (December), and due to the fact that only a small number of the 1- to 3-year-old children eligible for the screening participated in the program, DOH recommended that another assessment of blood lead be scheduled for July, August, or September.

NETCHD developed plans to screen children aged 1 to 3 from the Northport and Onion Creek School Districts. The health district advertised the clinic, arranged the location and scheduling, and staffed the clinic during the blood drawing. The screening clinic took place on September 16 and 17, 1993. Blood samples were drawn from 40 children, seven of whom were in the targeted 1 to 3 age group. Three children were 6 years old and 30 children were over 6 years of age. Thirty-nine of the children were from the Northport School District, and one child was from the Onion Creek School District. None of the children had blood lead levels above the detection limit of 5 micrograms of lead per deciliter of blood. Centers for Disease Control and

Prevention (CDC) recommends that blood lead levels in children be below 10 micrograms of lead per deciliter of blood.

Two of the children participated in both the December and the September screening. NETCHD reported that one child who had a measurable blood lead level (7 microgram of lead per deciliter of blood) in the December 1992 screening, had blood lead levels below the detection limit in the September, 1993 screening. The second child had blood lead levels below 5 microgram of lead per deciliter of blood on both screenings.

CDC and DOH believe that children between the ages of 6 months to 6 years are at highest risk for lead poisoning from exposure to contaminated soil and lead in paint. Children between 1 and 3 years are at higher risk than those between 4 and 6 years, because they have more hand to mouth contact, their blood-brain barrier is not completely formed, and their nervous system is still developing. Children over 6 years old have much less hand to mouth contact, the blood-brain barrier is complete, and nervous system development is complete.

Blood Lead Conclusions

DOH recommends that further monitoring of blood of children aged 1 to 3 be done during the appropriate season of the year that reflects maximum exposure. Since only ten of the children screened were in the 6 month to 6 year age group, and only seven of the children were in the most susceptible 1 to 3 year age group, the major population of toddlers may not have been evaluated. At present, the question of lead exposure to small children exposed to lead-contaminated soil in the Northport area has not been fully addressed.

DOH recommends that an active educational effort in the community be undertaken to raise community awareness regarding the danger of lead exposure to small children. Parents of infants and toddlers should be counseled during their participation in the monthly health district's clinic and Northport clinic.

NETCHD plans to continue providing the Northport community with information on the importance of lead testing. Brochures will be available at the clinics, the Northport School District, and other resource information offices. Lead screening for children under age 3 will be made available on an individual basis as requested by parents. Blood will be drawn as arranged by the health district and the DOH State Laboratory will perform the lab analysis. DOH supports these efforts and will work with NETCHD in the awareness program.

10. ***Air monitoring and health evaluations.***

Introduction

In the winter of 1992, Ecology, at the request of the DOH, initiated a study of air quality in the Northport area in order to help identify the cause of health problems reported by local residents.

Concern had been expressed at public meetings that a variety of illnesses experienced by members of community might have a relationship to pollution in the area.

Ecology agreed with DOH and local residents that these concerns were important and that air quality data could provide helpful information. Ecology, therefore, gave a high priority to the Northport air quality study and provided both funding and staff time. It is estimated that Ecology will have spent 2,500 hours of staff time, and $30,000 in lab analysis costs and for various support activities to evaluate and model the area's air quality.

Ecology's air monitoring study was conducted in two phases. Phase I air sampling lasted from December 15, 1992 through February 13, 1993. Phase II was conducted from August 10 through October 30, 1993. The purpose of Ecology's study was to determine the concentrations of particulates including metal pollutants in the air in the Northport and Kettle Falls areas. The samples collected were analyzed for 31 metals and the data for all 31 metals are included in the Appendix G of this report. Lead, arsenic, cadmium, copper, zinc, antimony, and manganese were looked at in more detail because of potential health impacts and suspicion that these could be emitted by local sources. A more detailed description of Ecology's study is included in Part A of this section, following this introduction.

DOH analyzed metals information collected by Ecology, especially the lead, arsenic, and cadmium. While the concentrations of lead did not violate the National Ambient Air Quality Standard (NAAQS) for lead, the concentrations measured were as high as any measured in highly industrialized areas of the state, such as Harbor Island, in Seattle. Lead, therefore, is considered to be of concern by DOH.

Arsenic and cadmium were of concern because both exceeded their respective ASIL values. The ASIL (Acceptable Source Impact Level) is an air concentration screening value derived form evaluation of health effect and cancer risk, with ample safety margins. As a screening tool, the ASIL value can be used to determine which contaminants are of health concern. If a measured environmental sample is equal to or less than the ASIL number, the pollutant is not of concern, since, by definition, the ASIL is a safe exposure level. When the ASIL value is exceeded, further evaluation to determine possible health impacts must be done.

The health evaluation for lead, cadmium and arsenic, entitled "Health Evaluation of Particulate Samples," is described in detail in Part II of this section.

PART A
NORTHPORT AIR MONITORING AND MODELING STUDY
DEPARTMENT OF ECOLOGY
AIR QUALITY PROGRAMS

In the winter of 1992, Ecology, at the request of DOH, initiated a study of air quality in the Northport area in order to help identify the cause of health problems reported by local residents.

The Department of Ecology's air monitoring study was conducted in two phases. Phase I, air sampling and analysis, lasted from December 15, 1992 through February 13, 1993. The primary purpose of Phase I was to identify maximum lead concentrations in the Northport-Kettle Falls area and provide these values to the Department of Health for its blood lead study.

Phase II of the study was conducted from August 10 through October 30, 1993 to determine the concentrations of lead, arsenic, and other metal pollutants in the air in the Northport and Kettle Falls areas. The metals chosen for evaluation were those suspected of originating either from the Cominco, Ltd. smelter at Trail, B.C. or from other sources in the immediate study area.

A more detailed description of both phases of the study is given below:

PHASE I (DECEMBER 15, 1992 THROUGH FEBRUARY 13, 1993)

During Phase I, Ecology set up air monitoring samplers at five sites in the study area--four were in the Northport area and one was in Kettle Falls (see Figure 1). Approximately 100 filters containing particulate matter (dust) were collected and analyzed for concentration of particulate matter and lead. Arsenic concentrations also were recorded.

The data collected and analyzed during Phase I are summarized in Table 5. The Phase I data indicated no violations of the federal and state lead standard, which is 1.5 micrograms per cubic meter - three month average, although the record lead concentrations were some of the highest recorded anywhere in the state during the Phase I time period. The term "micrograms per cubic meter" represents a pollutant concentration that is in the range of a millionth of a gram of the pollutant in a cubic meter of air. There is no federal or state standard for arsenic, yet this metal also recorded the highest values measured anywhere in the state during the Phase I study period.

The conclusions reached during Phase I were:

- In the study area lead and arsenic concentrations were the highest measured anywhere in the state during the Phase I.
- Additional monitoring and analysis should be performed to evaluate the concentrations of other potentially significant metals in the study area.

Phase II (August 10, 1993 through October 30, 1993)

Because of higher than anticipated lead and arsenic concentrations obtained during Phase I, Ecology, with the concurrence of DOH, decided to continue with additional air monitoring in the Northport - Kettle Falls area. Additional air monitoring was necessary to identify various metal concentrations in the study area and help relate these concentrations with known sources of metals up and down the Columbia River Valley in the vicinity of Northport and Kettle Falls.

Ecology also decided to conduct a computer air quality modeling assessment during Phase II. A computer-generated air quality model was considered useful because once the appropriate weather, terrain, and source pollutant emission information is incorporated, the model can "predict" the concentration in the study area of various pollutants emitted by the sources. This can be done for any number of weather conditions and pollutant emission rates. The computer model can also identify conditions under which maximum pollutant concentrations could occur. The potential health impacts of these maximum concentrations can then be determined.

TABLE 5
PHASE I
AIR QUALITY MONITORING STUDY

RECORDED VALUES IN
MICROGRAMS PER CUBIC METER

SITE	PARTICULATE	LEAD		ARSENIC
	MAXIMUM VALUES	MAXIMUM VALUES	AVERAGE* VALUES	MAXIMUM VALUES
Paparich - (Sequential Sampler)**	41.55	1.66	0.20	0.25
Paparich - (TSP Sampler)**	31.00	2.16	0.61	0.09
Arnold - (TSP Sampler)	36.00	1.02	0.31	0.09
Jackman - (TSP Sampler)	54.00	1.91	0.70	0.12
Worthen - (TSP Sampler)	56.00	2.29	0.92	0.21
Kettle Falls - (TSP Sampler)	40.00	0.44	0.17	0.02

*NOTE: Lead standard is 1.5 micrograms per cubic meter averaged over 3 months. Phase I average values are averages from the December 15, 1992 through February 13, 1993 sampling period.

**NOTE: Sequential Samplers measure dust particles ten-thousandths of a meter in diameter and smaller and sample for this particulate size every hour. TSP Samplers measure Total Suspended Particulate regardless of size and sample on a one day out of six days cycle.

AIR MONITORING SITE SELECTION

For Phase II, seven air monitoring sites were selected (see Figure 2) based on two criteria:

- Suspected areas of high metals concentrations in the Northport and Kettle Falls area, and
- A north-south distribution of monitoring sites from Trail, B.C. to Kettle Falls to evaluate the study area concentration patterns of metals originating from the Cominco, Ltd. smelter at Trail, B.C.

All the samplers used were particulate samplers, which filter out and collect particles. Two types of particulate sampling were performed:

- Total Suspended Particulate (TSP) sampling, which collected all sizes of air particles. TSP sampling is EPA designated method for determining lead concentrations, and
- PM10 sampling, which only collected particles that are 10-thousandths of a meter in diameter or smaller. These small particles are easily ingested into the lungs where they remain lodged along with the pollutants that they contain.

Two out of the seven Ecology samplers were located, one each, at the Cominco, Ltd. sampling sites at Trail, B.C. and at Waneta, B.C. Both of these were PM10 samplers.

On the Washington side of the border, five air monitoring sites were established: Northport (Paparich Farms and Worthen); China Bend (Hawks and Onion Creek School); and Kettle Falls (Washington Water Power Energy Plant).

Northport, China Bend, and Kettle Falls sites were selected to help determine the impacts of the Cominco, Ltd. smelter as well as the impacts of metal contributions from local dirt roads and local mining activities. The Worthen residence site was again selected to continue investigating the maximum lead concentrations found during Phase I. Finally, the Onion Creek School was chosen to allow Ecology and DOH to better evaluate the impacts of metals on one of the more sensitive segments of the local population - children.

At the Paparich site, one of the three PM10 samplers located there collected data every day of the Phase II study period. All the other samplers used in the study collected data one out of every six days during the study period. This one-in-six-day schedule is consistent with EPA's national sampling schedule. A description of the Phase II air monitoring sites, their locations, and the type of samplers used is contained in Table 6.

Selection Of Metals For Analysis

Ecology, working with DOH, identified seven metals for analysis during Phase II of the study. These seven included:

- Cadmium (Cd)
- Copper (Cu)
- Zinc (Zn)
- Antimony (Sb)
- Lead (Pb)
- Arsenic (As)
- Manganese (Mn)

Of the seven metals listed above, lead, zinc, cadmium, arsenic, and antimony are typically emitted by smelters like the one at Trail, B.C. Manganese was selected because it was identified as a potential pollutant from the power plant facility at Kettle Falls. Copper was chosen because of potential contributions from local mining activities.

Data Analysis And Results

A complete listing of all the data collected and analyzed during Phase II of Ecology's air monitoring study is included in Appendix G. The data analysis and results are presented below:

- **Particulate Data**

A total of 135 filters were analyzed for particulates during this phase of the study. Each filter represents data from one 24 hour sampling period. A summary of the particulate data gathered during the Phase II study is presented in Table 7. The state standard for both Total Particulate (TSP) and PM10 is 150 micrograms per cubic meter for a 24 hour period. Table 7 data shows that the maximum particulate concentrations occurred on September 4, 1993, at the Paparich site where the three samplers at this location (TSP, PM10 reference, and PM10 sequential) measured values of 62, 64, and 51 micrograms per cubic meter, respectively.

TABLE 6
PHASE II AIR QUALITY MONITORING STUDY SITE LOCATIONS

FIXED MONITORING SITES

1. Northport site: Paparich, Louie
Site number: 3300002A
Address: 4598 Mitchel Road
Northport WA, 98157
Parameters measured: PM-10 (from Reference and Sequential Samplers), TSP, and meteorology. (wind speed, wind direction, and temperature for the period August 10 through September 27, 1993 only)

2. China Bend site: Hawks, Bob
Site number: 3300005A
Address: 3112 Highway 25 N.
Northport WA, 99157
Parameter measured: PM-10

3. Kettle Falls site: WA Water Power Energy Plant - Contact: Dale Snyder
Site number: 3300004A
Address: Highway 395 and Peach Crest Road
Kettle Falls WA, 99141
Parameter measured: PM-10

PORTABLE PM-10 MONITORING SITES

4. Trail Public Works
Located in the city yard at Glenmerry, a suburb of Trail B.C. This sampler is co-located with a TSP sampler that Cominco, Ltd. operates. There are sand piles about 50 yards away from the sampler. There is little traffic around the sand piles except during the winter. Sampler is about 2 1/2 miles southeast of the Cominco smelter in Trail B.C.

5. Waneta
This site is about 1/2 mile north of the confluence of the Pend Oreille and Columbia rivers. Sampler is at Cominco's water testing site along the Waneta-Nelway Road. Sampler is located about 20 feet off of the road. Traffic is light because border crossing hours are from 8:00 am to 5:00 pm. There are some train tracks about 50 yards from the monitoring site.

6. Worthen Residence
4765 D. Mitchell Road, Northport WA
Sampler was attached to a Ponderosa Pine tree next to the garden. This was the best open area around the yard. The sampler was about 35 yards to the west of where the TSP was located during the winter 1992 monitoring season.

7. Onion Creek School
Sampler was attached to the play field backstop in the school yard. Area is fairly open and away from trees and buildings. Gravel road going to the Van Stone mine is about 300 to 400 yards away from the sampler.

TABLE 7

PARTICULATE VALUES IN MICROGRAMS PER CUBIC METER

Date	SAMPLER LOCATIONS								
	Paparich			China Bend	Kettle Falls	Trail B.C.	Waneta	Worthen	Onion Creek
	TSP Sampler	PM-10 Reference Sampler	PM-10 Sequential Sampler	PM-10 ReferenceSampler	PM-10 Reference Sampler	PM-10 Portable Sampler	PM-10 Portable Sampler	PM-10 Portable Sampler	PM-10 Portable Sampler
13Aug	26	22	18	14	31				
17Aug	12	11	--	12	13				
23Aug	31	19	--	14	33				
29Aug	18	14	12	23	14				
4Sep	62	64	51	17	31				
10Sep	--	49	39	22	42				
16Sep	8	6	10	6	8				
22Sep	13	9	10	8	16	37	35	12	--
28Sep	28	22	21	14	28	25	36	37	--
16Oct	--	12	14	15	9	--	--	--	--
22Oct	--	22	19	20	30	36	35	37	--
28Oct	--	17	17	16	20	--	36	12	35
Averages	26	24	21	16	23	Note: Sampling started September 22 at all these portable PM-10 sites.			

REFERENCE PM-10

Instrument certified by EPA for use in sampling for PM10 (particulates ten thousandths of a meter in diameter and smaller).

SEQUENTIAL PM-10

This instrument also samples for PM-10. However, it is not certified by EPA, but does have the capability to sample on two sets of filters, for six days in a row.

These Phase II maximum particulate concentrations are well below the 150 micrograms per cubic meter state particulate standard.

The arithmetic averages of the Table 7 particulate data from the three Paparich site samplers in micrograms per cubic meter were:

TSP	26
Reference PM10	24
Sequential PM10	21

These values are quite low as are the PM10 averages for China Bend and Kettle Falls (16 and 23 micrograms per cubic meter, respectively).

Data were collected at the Onion Creek School only on September 28, 1993, due to operating difficulties with the monitoring equipment. The particulate value for that day was 35 micrograms per cubic meter. This PM10 value is below the standard, but at or above the levels at the other monitoring sites. This indicates a possible source of particulates near to the monitoring site, probably the dirt road next to the school.

Table 7 arithmetic average particulate data show no significant difference between the TSP and the PM10 values, which could point to a fairly uniform distribution of fine particles within the study area. Normally TSP concentrations average about one-third higher than fine particulate (PM10) values, because TSP values represent all sizes of particles including the coarser material. But in this case, the measured values were about the same. This may mean that all the samplers were situated far enough away from local particulate sources to allow the heavier particles to settle out before being collected by the samplers. The PM10 and smaller air particles have potentially a more significant health impact because of their small size and the ease with which they collect in the lungs.

Table 7 particulate data also indicate that on September 28, 1993, when all seven samplers were operating, there is a general trend of reduced particulate concentrations downwind of the Cominco smelter. However, there are exceptions to this trend as well. For example, the Trail, B.C. data, which represents a site closest to the Cominco, Ltd. smelter is sometimes less than the values from the Waneta site which is farther away. This may be due in part to the fact that the Trail site is too close to the smelter and more of the smelter's plume touches down further downwind. In addition, the particulate concentrations at Kettle Falls are usually higher than those from the China Bend site which is closer to the smelter. This is probably due to local Kettle Falls sources contributing fine particulates and increasing Kettle Falls sampler values.

- **Metals**

Metal analysis was performed by Ecology's Manchester Environmental Laboratory (Manchester Lab) on 105 filters gathered from the seven sampling locations established during Phase II of the air monitoring study. The Manchester Lab analyzed each filter for 31 separate metals including the seven metals identified as critical to the Phase II study (cadmium, copper, zinc, antimony, lead, arsenic, and manganese).

These seven were considered critical because of health considerations and suspicions that these were being emitted by sources in the study area. Data for all 31 metals from the 105 filters analyzed is appended to this report. All 31 metals were analyzed because the analytical process used at the Manchester Lab automatically analyzed each filter for all 31 metals.

However, even though the filter samples were analyzed for all 31 metals, the Manchester Lab only performed Quality Assurance on the seven critical metals (cadmium, copper, zinc, antimony, lead, arsenic, and manganese). For a description of the laboratory methods of analysis and Quality Assurance procedures used, please refer to the appended data section. Quality Assurance procedures included calibrating the laboratory instruments using samples with known concentrations of the above seven metals. This procedure was followed at the beginning of the analysis for each group of filters; again, after each 10 filters were analyzed; and finally at the end of each group of filters to ensure that all the lab results for the seven metals were accurate. Quality Assurance was not performed on the other 24 metals because Quality Assurance procedures are time-consuming and costly and it made sense to concentrate Ecology's limited resources on the seven metals of concern.

METALS ANALYSIS

The results of the laboratory analysis for the seven critical metals showed that the concentrations ranged from zero to levels higher than normal for typical rural settings. However, these higher concentrations were not unexpected given the type of industry (mining and smelting) found in the study area.

The **maximum** concentrations of the seven critical metals found during Phase II of the air monitoring study are shown in Table 8 below:

TABLE 8
PHASE II AIR QUALITY MONITORING STUDY
MAXIMUM METAL CONCENTRATIONS
IN MICROGRAMS PER CUBIC METER

SITE	LEAD	ARSENIC	CADMIUM	COPPER	ZINC	ANTIMONY	MANGANESE
Trail	.7412	.0679	.0400	.0020	1.6682	.2670	.0170
Waneta	1.0363	.1164	.0474	.0124	1.8764	.1811	.0111
Worthen	.7968	.0896	.0397	.0090	1.4921	.1196	.0146
Paparich	.5135	.0691	.0282	.0327	.8758	.0893	.0308
China Beach	.3343	.0481	.0186	.0351	.4193	.0499	.0096
Onion Creek	.0773	.0476	.0048	.0152	.1079	.0000	.0223
Kettle Falls	.1675	.0313	.0086	.0256	.1779	.0363	.0278

It is important to remember that the federal and state standard for lead is 1.5 micrograms per cubic meter average concentration over a three month period. Also, there are no federal or state standards for the other six metals (arsenic, cadmium, copper, zinc, antimony, or manganese). In these cases, Ecology uses what are called "Acceptable Source Impact Levels" or "ASIL." ASILs are outdoor concentration values of various air pollutants. ASIL concentrations are used by Ecology as "screening" levels, i.e., if the air concentrations are equal to or less than the ASIL values, the "risk" to the exposed population from that particular pollutant is considered negligible. If the pollutant concentrations are higher than the ASIL value, additional analysis are necessary to evaluate the risk to the exposed population.

Table 9 below lists the ASIL values for various metals:

TABLE 9 EXAMPLES OF ACCEPTABLE SOURCE IMPACT LEVELS (ASILS) IN MICROGRAMS PER CUBIC METERS	
ASIL VALUES	
Arsenic	.00023 (annual average)
Cadmium	.00056 (annual average)
Nickel	.00210 (annual average)
Antimony (Sb)	1.7 (24 hr. average)
Barium (Ba)	1.7 (24 hr. average)
Cobalt (Co)	0.17 (24 hr. average)
Copper (Cu)	3.3 (24 hr. average)
Iron (Fe)	17.0 (24 hr. average)
Manganese (Mn)	0.4 (24 hr. average)
Selenium (Se)	0.67 (24 hr. average)
Silver (Ag)	0.33 (24 hr. average)
Tantalum (Ti)	17.0 (24 hr. average)
Tin (Sn)	6.7 (24 hr. average)
Zinc (Zn)	17.0 (24 hr. average)

The relationship between existing standards, ASILS, and the concentrations of the seven critical metals measured during Phase II of the air monitoring study is described below:

LEAD

During the Phase II air monitoring study (third quarter, 1993), the **highest** lead concentration measured at the Paparich site was 0.5135 micrograms per cubic meters (see Table 8) and the lead **average value** for the study period at this site was 0.1374 micrograms per cubic meter. The reason why data from the Worthen site were not used in the analysis was that the Worthen site does not meet EPA/state monitoring site criteria because trees were too close to the monitor.

This average value at the Paparich site is much less than EPA/state lead standard of 1.5 micrograms per cubic meter (quarterly average). However, this Paparich lead level is comparable to the highest average lead concentrations found at the Harbor Island-Texaco site (0.1787 micrograms per cubic meter), which is a highly industrialized area in Seattle.

In addition, the average lead concentration at the Paparich site during Phase I of the air monitoring study (December 20, 1992 to March 13, 1993) was 0.6054 micrograms per cubic meter. While the Phase I concentration is still much lower than the standard, the reason for the more than four times greater Phase I lead concentration compared to Phase II is not known. It could be due to greater Cominco, Ltd. smelter lead emissions, different seasonal meteorological conditions, the fact that in Phase II a more accurate method was used to analyze for lead, or any combination of the above.

COPPER, ZINC, ANTIMONY, AND MANGANESE

A comparison of the maximum concentrations of copper, zinc, antimony, and manganese measured at the Paparich site during Phase II to the corresponding ASIL values for these metals is shown in Table 9 below:

TABLE 10

PHASE II AIR QUALITY MONITORING STUDY

METALS CONCENTRATIONS IN MICROGRAMS PER CUBIC METER

	ASIL VALUES	MAXIMUM PAPARICH VALUES
Copper	3.3	0.0327
Zinc	17.0	0.8758
Antimony	1.7	0.0893
Manganese	0.4	0.0308

All four of the above metals had concentrations much lower than the respective ASIL "screening" values. Consequently, Ecology determined that these four metals did not require more study.

ARSENIC AND CADMIUM

Both arsenic and cadmium concentrations in the Northport study area appear to exceed their respective ASIL values significantly. This could be somewhat misleading because the arsenic and cadmium ASIL values are **yearly averages** whereas the Phase II sampling period only lasted **42 days**. Normally, daily maximum pollutant concentrations tend to be much higher than quarterly average concentrations which, in turn, tend to be higher than yearly average concentrations. For example, the maximum **24-hour** arsenic value measured at Waneta is 0.1164 micrograms per cubic meter. If the data from the Waneta site are averaged over the 42 days of the Phase II study, this average value drops to 0.0800 micrograms per cubic meter supporting the notion that quarterly maximum averages tend to be lower than daily maximum averages. There is a strong likelihood that, had Phase II lasted a whole year, the resulting **yearly** arsenic concentrations would be much lower still, perhaps much closer to the ASIL values.

This trend of reduced concentrations with longer averaging times also appears to hold for cadmium. For example, the maximum 24-hour cadmium value at Waneta was 0.0474 micrograms per cubic meter. The 42 day average cadmium concentration on the other hand, was 0.0076 micrograms per cubic meter.

The relevancy of these arsenic and cadmium values to local health concerns is addressed in DOH's section of this report.

Analysis of the other 24 metals showed a good relationship between these metals and particulate concentrations. Those metals that are of a crustal nature (metals found normally in the earth's crust), such as aluminum, calcium, iron, magnesium, manganese, titanium, and strontium all increase as particulate levels increase. Dust on the ground that is picked up and suspended in the air by passing traffic, for example, could contain these metals. The Washington Water Power Energy Plant in Kettle Falls, a potential source of manganese, does not appear to have much, if any, effect on the monitored manganese levels at the Kettle Falls site.

Metal values for the seven metals from the Onion Creek School site were low during the one day that data was obtained during the Phase II of the study even though they were high at other sites during the same day. This implies the school children are probably not being exposed to these metals nearly as much as those children in other areas of the study.

COMINCO, LTD. NORTHPORT AIR MONITORING DATA

Cominco, Ltd. staff also sampled the air at Northport for TSP and PM10 from August 1993 through December 1993. Cominco, Ltd. sampling results are shown in Table 11. A comparison between Cominco, Ltd.'s measured values for particulates and four metals (lead, zinc, cadmium, and arsenic), with Ecology's Paparich data shows good agreement and provides confidence that both data are accurate.

A comparison of the data collected by Cominco, Ltd. at its Northport site with Ecology's Paparich site data showed a very close match, well within the range of values expected for sites not located right next to each other (See Figures 3). The analysis does not cover all seven metals because Cominco, Ltd. only analyzed for lead, zinc, cadmium, and arsenic. The weights for the TSP and PM10 do not match however, indicating a possible influence from a local source, possibly vehicular traffic near the Cominco, Ltd. monitoring site.

TABLE 11
COMINCO LTD. NORTHPORT DATA
IN MICROGRAMS PER CUBIC METER
MAXIMUM VALUES

B.C. SITES	PARTICULATES	Pb	As	Cd	Zn
B.C. Northport/PM-10	43	0.48	0.06	0.02	0.87
B.C. Northport/TSP	58	0.53	0.07	0.03	1.2

MODELING

Because the air monitoring study was conducted using a limited number of sampling locations (7 sites), Ecology decided to conduct a computer air quality modeling simulation of the study area to determine the distribution of metal pollutant concentrations throughout the area.

The simulation used two separate computer models. One is called the Colorado State University Mesoscale Model (CSUMM) which calculates wind speeds and directions in mountainous terrain based on information provided by local weather stations (Spokane, Washington; Prince George, B.C.; and Edmonton, Alberta in this case).

The other model, called MESOPUFF II, uses the information developed by CSUMM (wind speed and wind direction) and the concentration of pollutants emitted from local sources to calculate the concentrations of pollutants in the area around and downwind of the sources.

Both of the above models were used to calculate the concentrations across the study area of the three metals, which the air monitoring study and previous studies showed might have health impacts (lead, arsenic, and cadmium). The modeling was done for September 28, 1993. Air quality data showed that during the three-day period (September 26, 27, and 28, 1993), the metals concentrations steadily increased and peaked on September 28, which was the worst air quality day of the Phase II study period.

Smelter production rates were obtained from Cominco, Ltd. for the September 26 to 28 period. The computer model then calculated the lead, cadmium, and arsenic concentrations throughout the study area for September 28 based on the meteorological conditions which occurred during that day and the actual concentrations of lead, cadmium, and arsenic measured at the seven monitoring sites. The assumption was made that the concentrations of the three metals on September 28 were the direct result of emissions of those metals from the Cominco, Ltd. smelter during the September 26-28 time period when the production levels of the smelter were nearly at maximum. These potential maximum concentrations of lead, cadmium and arsenic were then used to evaluate local health risks.

Ideally, the above modeling would be performed using an entire year's worth of Cominco, Ltd. operating data and associated wind and weather information to determine the maximum smelter impacts on the study area. However, the resources necessary for such an analysis are well beyond the scope of this study.

Production rates reported by the Cominco, Ltd. smelter for the September 26, 27, and 28, 1993 time period indicate almost full production rates. During that time, the air quality (CSUMM) model predicted that winds in the study area affecting the Cominco plume should blow to the southwest (see Figure 8).

The CSUMM meteorological model showed that the winds in the study area and especially along the valley can vary in both speed and direction hourly, daily, and seasonally. In addition, the model predicted that wind speed and direction can vary with height above the valley floor. The boundary between these low level and high level winds can also rise or fall depending on the time of day and various meteorological conditions.

For example, the CSUMM model predicted that on September 28, 1993, the low level winds would be blowing down the valley between Northport and Kettle Falls in generally a southwesterly direction. At the same time, however, the model predicted the direction of upper level winds to be more to the south and southeast.

These model wind results are supported to some extent by observations of local citizens who have reported smoke blowing in two directions from stacks of different heights.

The above model wind results are also supported by an in-depth meteorological study done in 1938-1939 as ordered by an international tribunal evaluating the impact of the Cominco, Ltd. smelter. This study also showed wind variation with heights and even suggested the possibility of multiple wind layers with upper and lower winds blowing in the same direction and winds at an intermediate level blowing in the opposite direction. Because predicting the impacts of pollutants is dependant on wind speed and direction information, the complexity of the wind in the study area makes pollutant impact predictions very difficult.

Nevertheless, an attempt was made to simulate the impact of the Cominco, Ltd. smelter on the study area. The model chosen, MESOPUFF II, is one of the newer computer models with the capability of simulating the impacts of pollutant sources in complex (mountainous) terrain.

MESOPUFF II has several important characteristics:

- The MESOPUFF II model cannot compute air concentrations until the emissions have traveled for 15 minutes from the source.
- The MESOPUFF II model is able to follow the curving flow of winds in complex terrain.
- The MESOPUFF II model simplifies the atmosphere by dividing it into two layers, which is not always realistic in the complex terrain of northeastern Washington.

Figures 9, 10, and 11, show the maximum potential concentrations of lead, cadmium, and arsenic in the study area as predicted by the MESOPUFF II model for the wind conditions that occurred on September 28, 1993. Because of the effect of these northeasterly winds on the plume from the Cominco, Ltd. smelter, the predicted arsenic, cadmium, and lead concentrations originating from the smelter were distributed as shown in these figures.

Care must be exercised in interpreting the modeling results shown in Figures 8, 9, 10, and 11. It is reassuring that the modeling results do appear to confirm the monitoring data results by predicting that winds and pollutants from the Cominco smelter can easily travel down the Columbia River Valley and produce moderately high pollutant concentrations in the study area generally consistent with the levels measured during the air monitoring study.

However, given the complexity of local topography and wind patterns, the lead, arsenic, and cadmium concentrations are approximations, at best, representing potential maximum concentrations possible in the study area for late summer - early fall conditions when the smelter is operating at nearly maximum output.

Figure 1

Northport Study Area - Phase 1

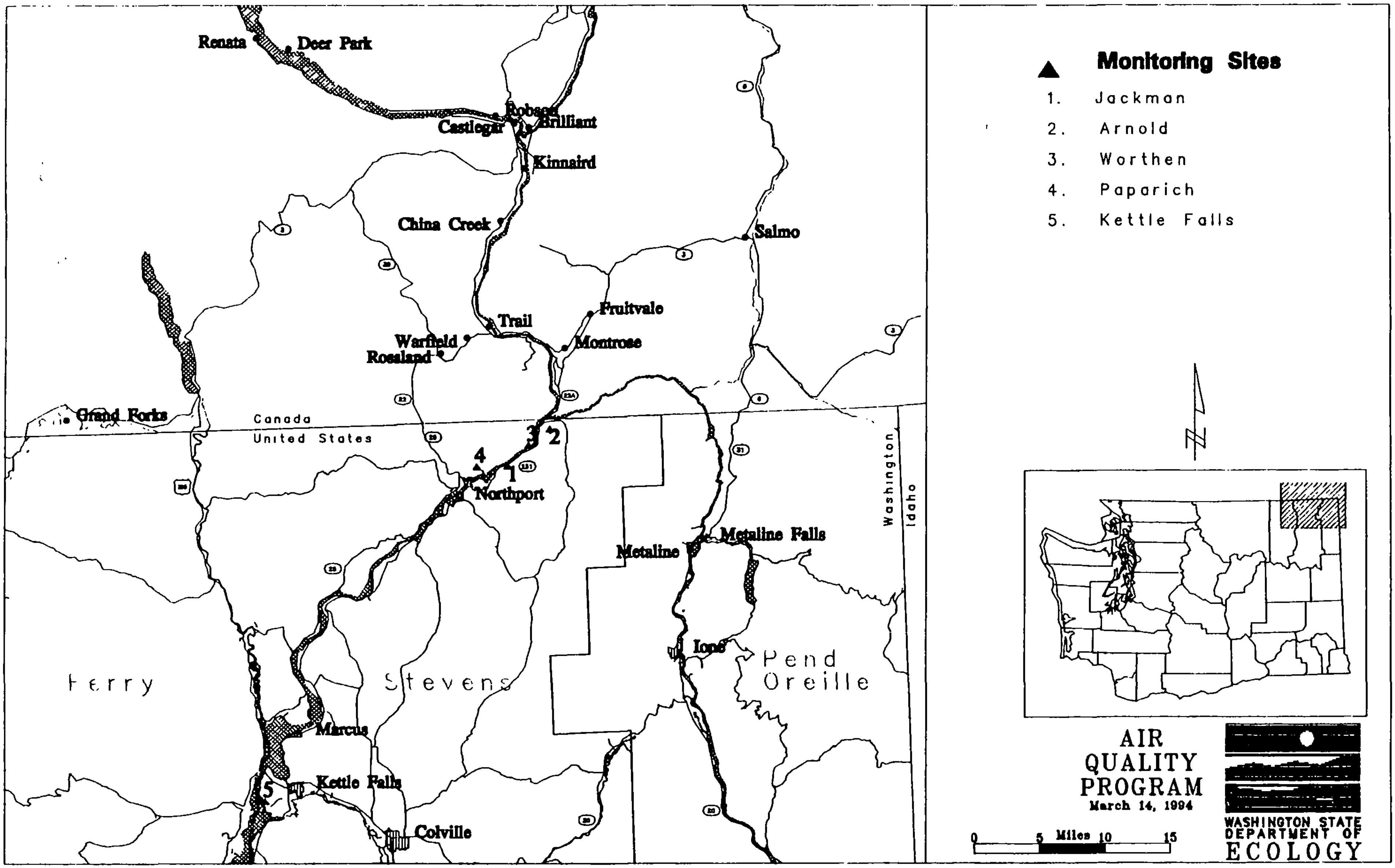
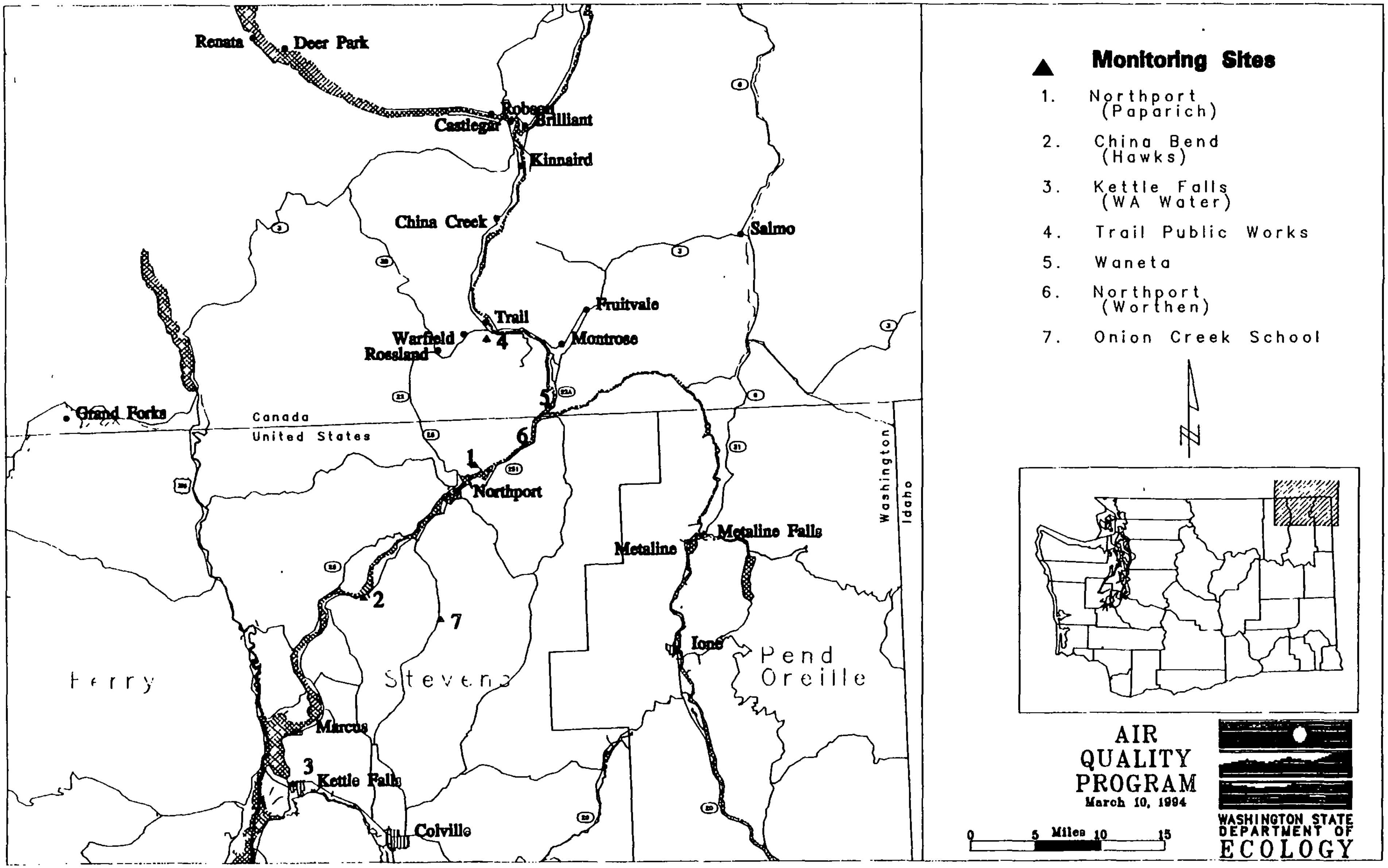
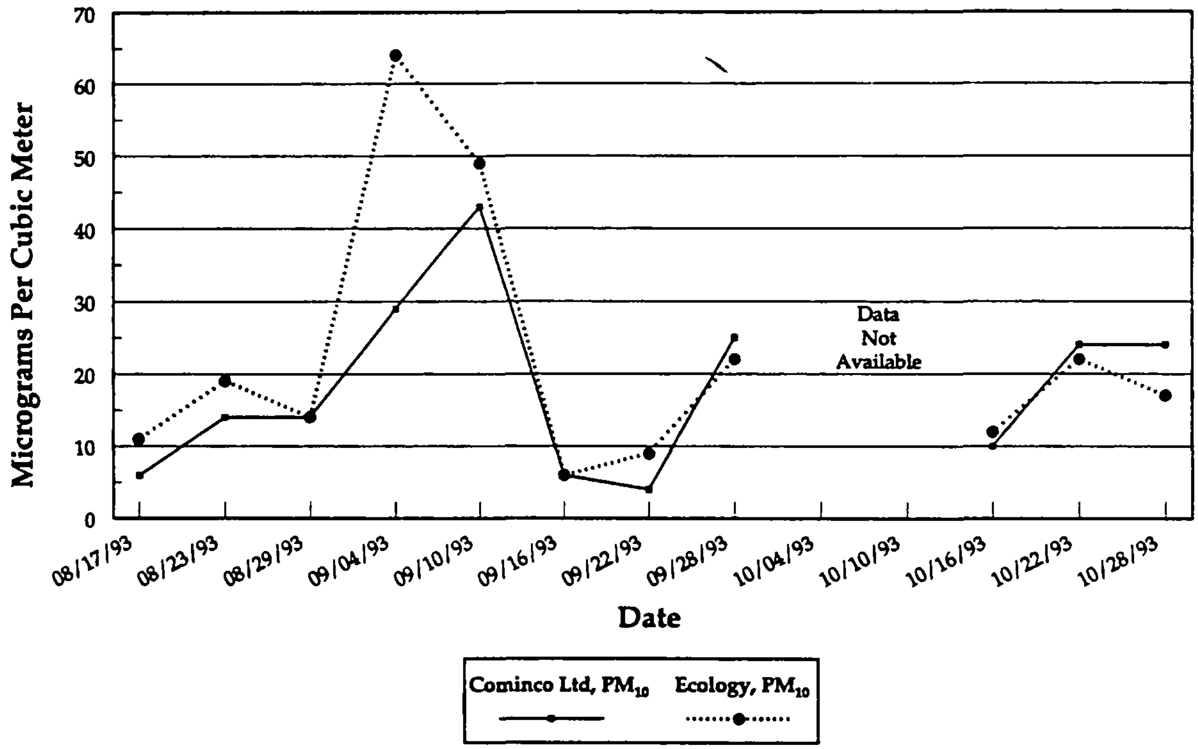


Figure 2

Northport Study Area - Phase 2



Comparison of Cominco Ltd. and Dept.of Ecology
Northport PM10 Sampling Data
Particulate Comparison



Comparison of Cominco Ltd. and Dept.of Ecology
Northport TSP Sampling Data
Particulate Comparison

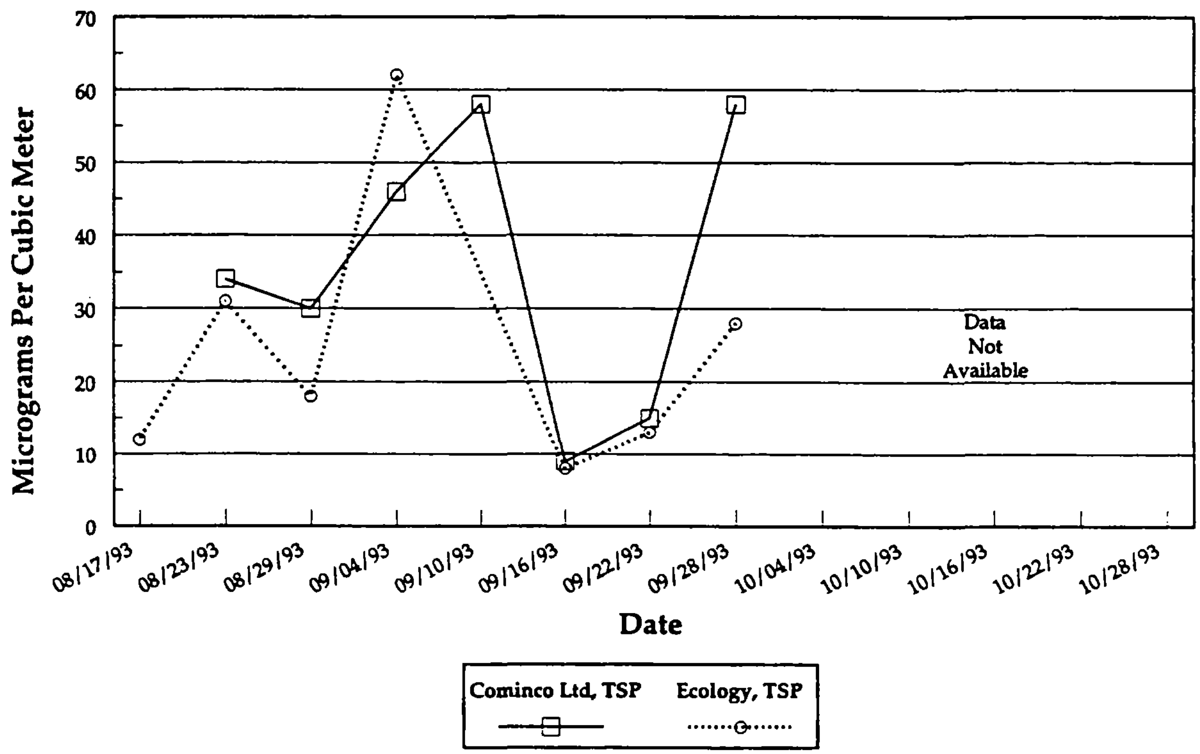
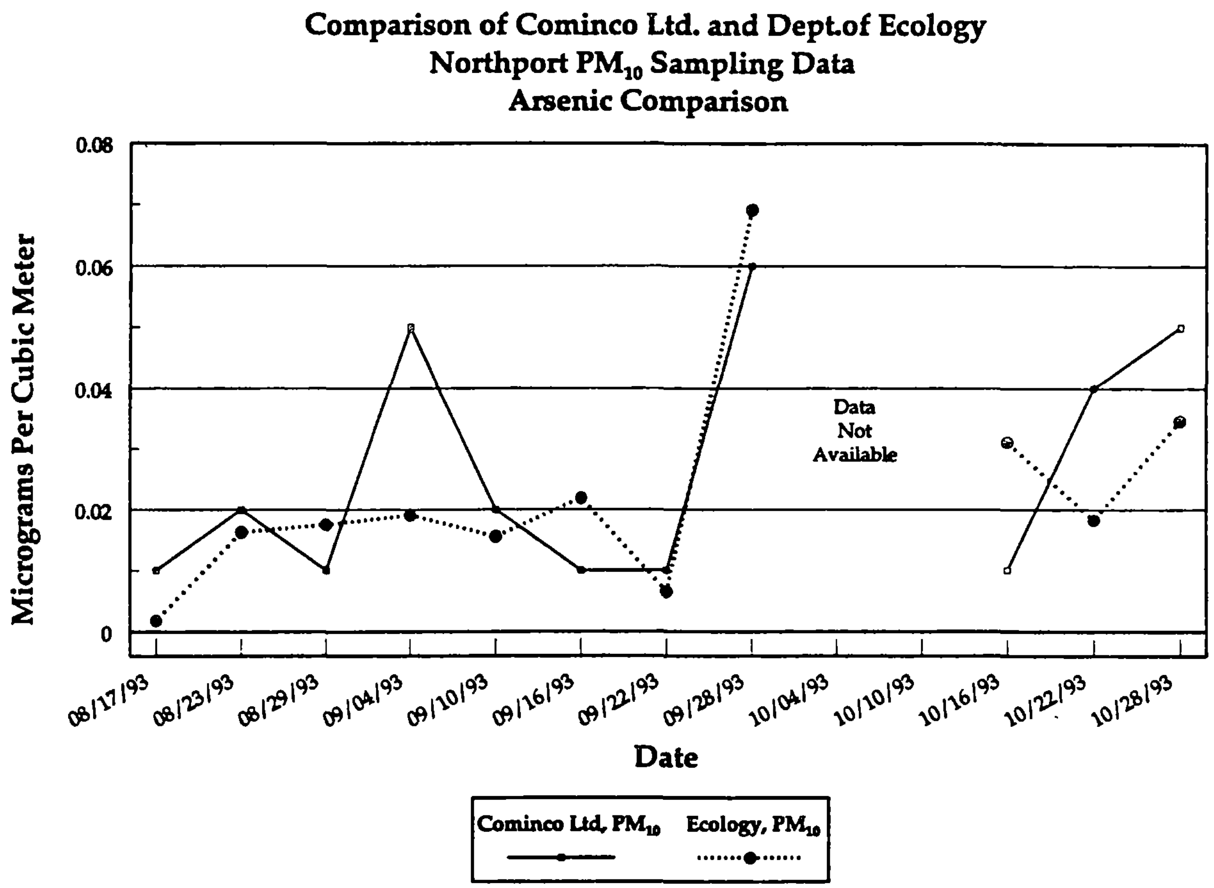
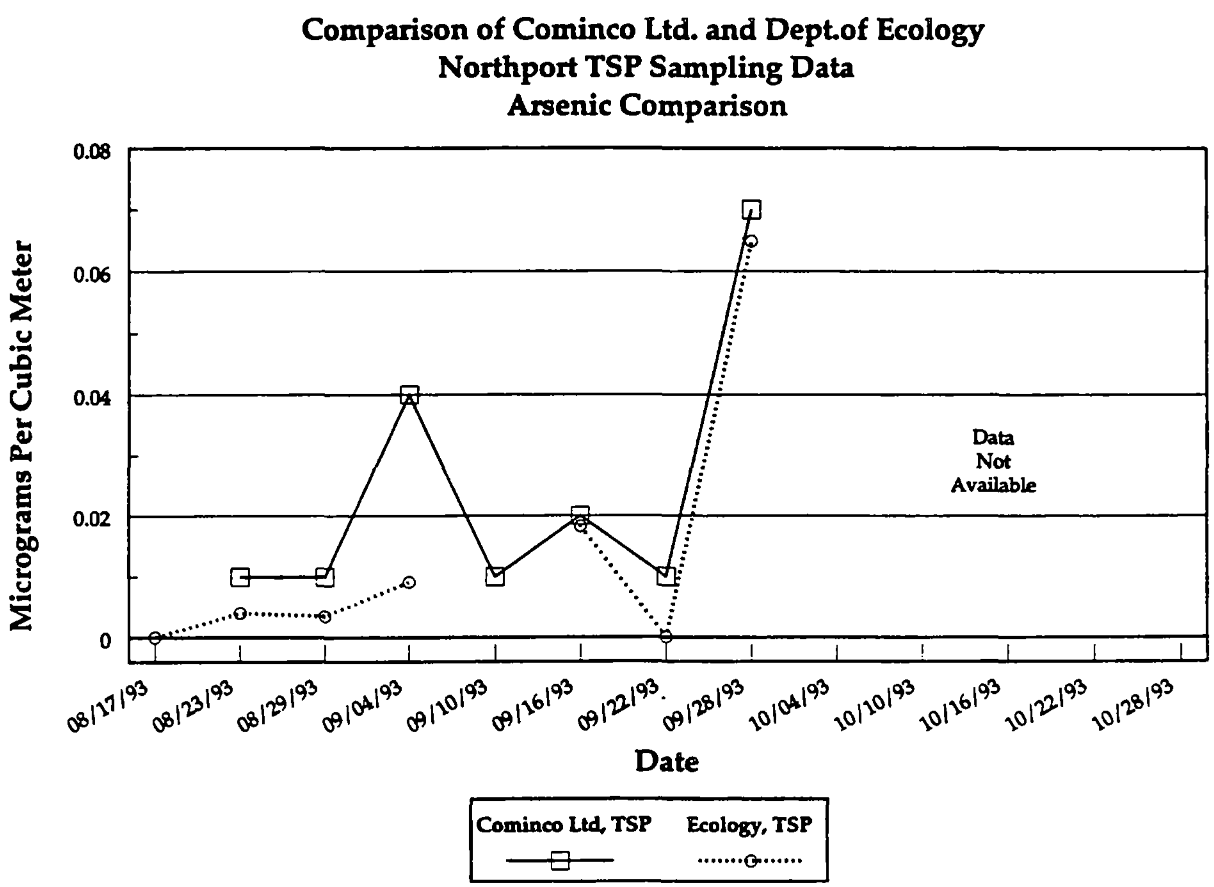


Figure 3

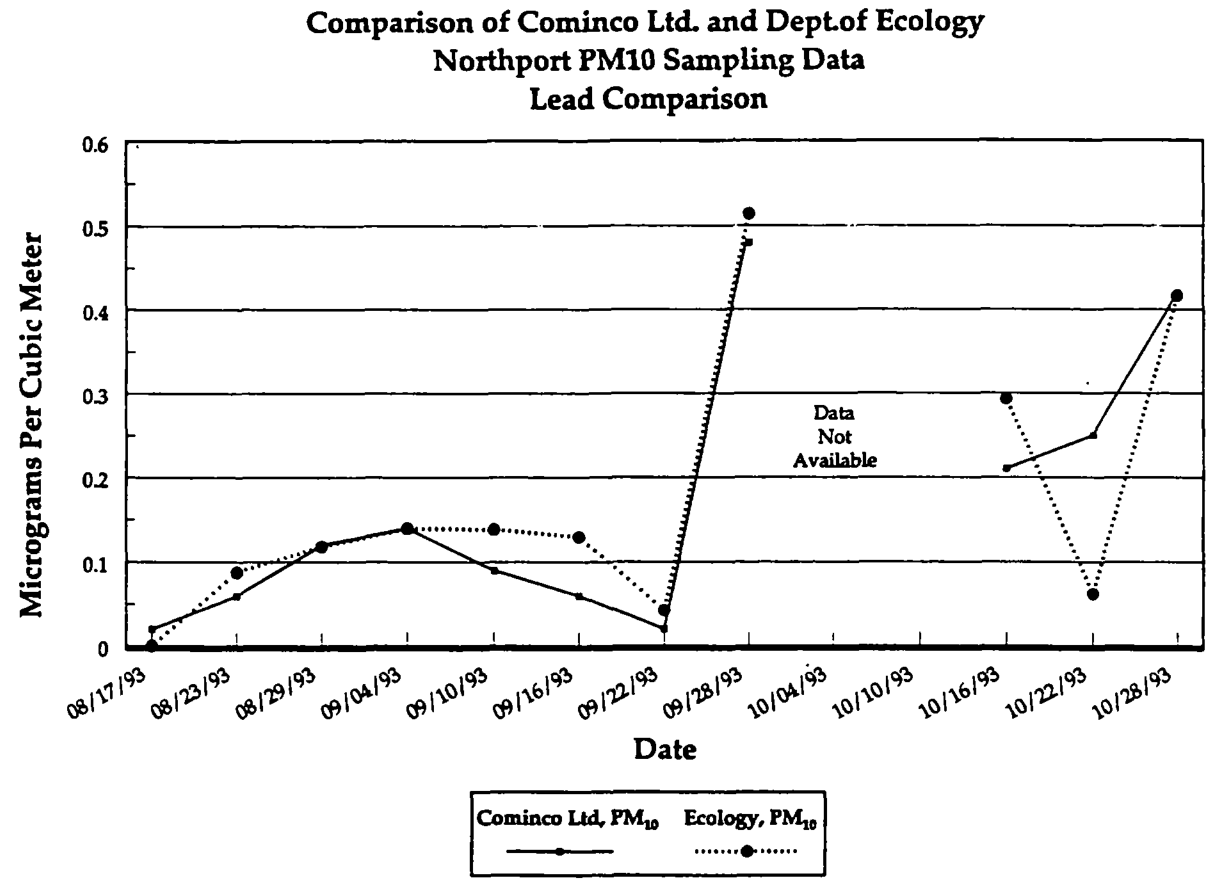


Comparison of Cominco Ltd. and Dept.of Ecology
Northport PM_{10} Sampling Data
Arsenic Comparison
Micrograms Per Cubic Meter
0.08
0.06
0.04
0.02
0
Data
Not
Available
08/17/93
08/23/93
08/29/93
09/04/93
09/10/93
09/16/93
09/22/93
09/28/93
10/04/93
10/10/93
10/16/93
10/22/93
10/28/93
Date
Cominco Ltd, PM_{10}
Ecology, PM_{10}



Comparison of Cominco Ltd. and Dept.of Ecology
Northport TSP Sampling Data
Arsenic Comparison
Micrograms Per Cubic Meter
0.08
0.06
0.04
0.02
0
Data
Not
Available
08/17/93
08/23/93
08/29/93
09/04/93
09/10/93
09/16/93
09/22/93
09/28/93
10/04/93
10/10/93
10/16/93
10/22/93
10/28/93
Date
Cominco Ltd, TSP
Ecology, TSP

Figure 4


Comparison of Cominco Ltd. and Dept.of Ecology
Northport PM10 Sampling Data
Lead Comparison
Micrograms Per Cubic Meter
0
0.1
0.2
0.3
0.4
0.5
0.6
Data
Not
Available
08/17/93
08/23/93
08/29/93
09/04/93
09/10/93
09/16/93
09/22/93
09/28/93
10/04/93
10/10/93
10/16/93
10/22/93
10/28/93
Date
Cominco Ltd, PM_{10}
Ecology, PM_{10}

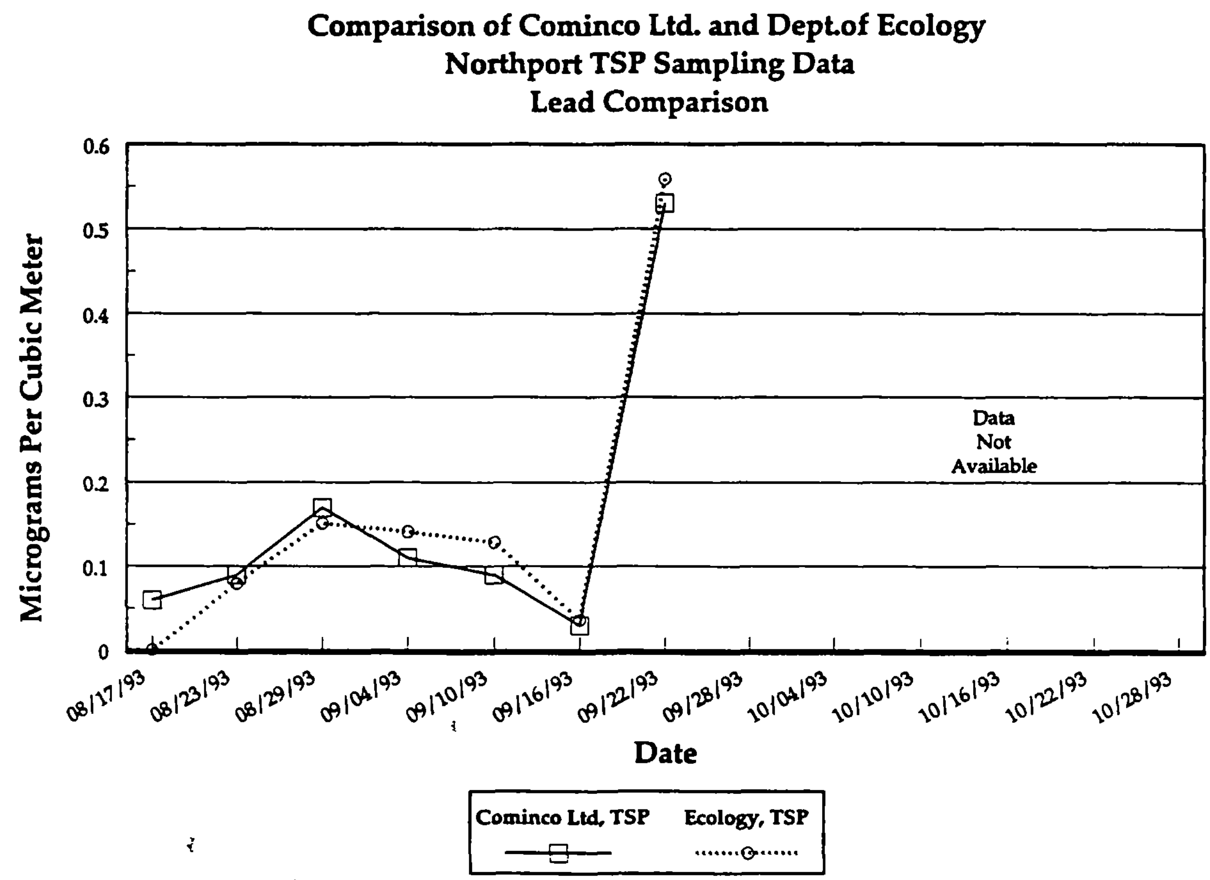
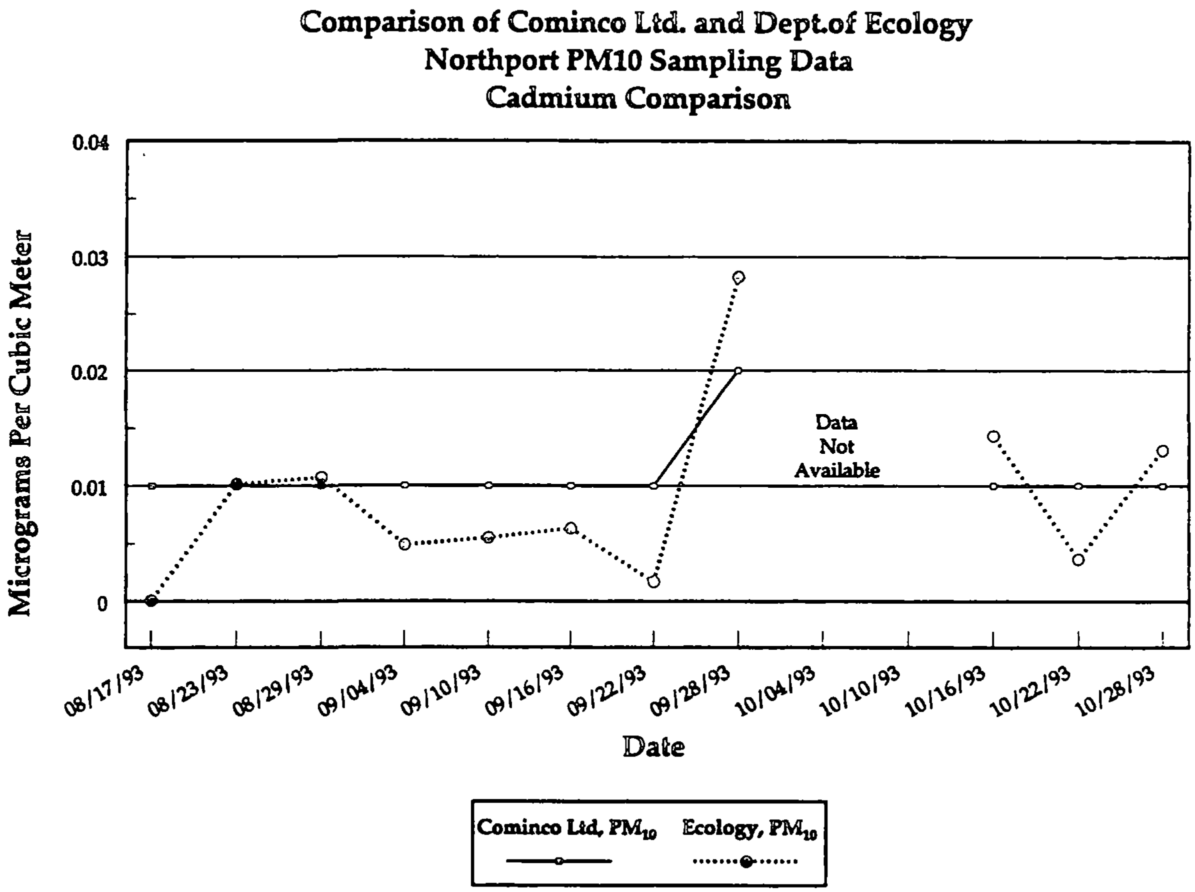
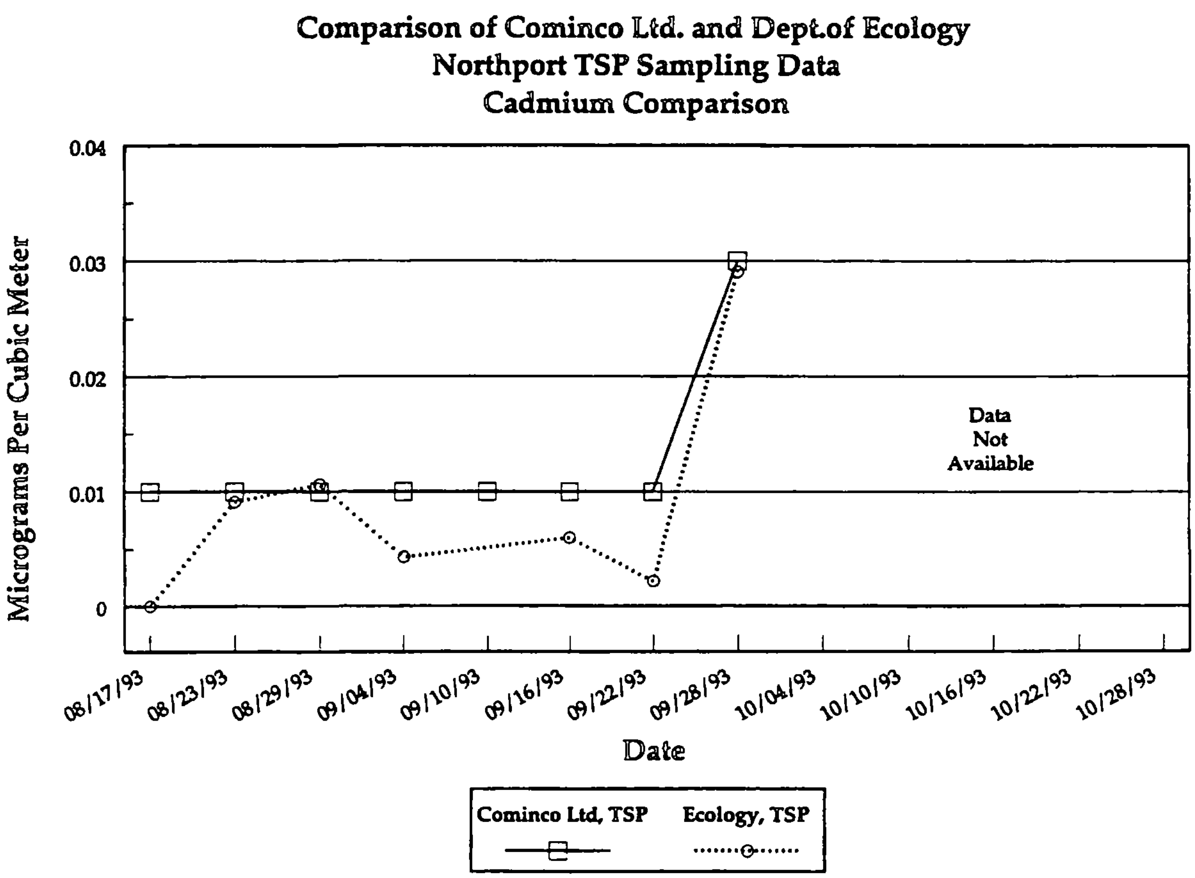

Comparison of Cominco Ltd. and Dept.of Ecology
Northport TSP Sampling Data
Lead Comparison
Micrograms Per Cubic Meter
0
0.1
0.2
0.3
0.4
0.5
0.6
Data
Not
Available
08/17/93
08/23/93
08/29/93
09/04/93
09/10/93
09/16/93
09/22/93
09/28/93
10/04/93
10/10/93
10/16/93
10/22/93
10/28/93
Date
Cominco Ltd, TSP
Ecology, TSP

Figure 5



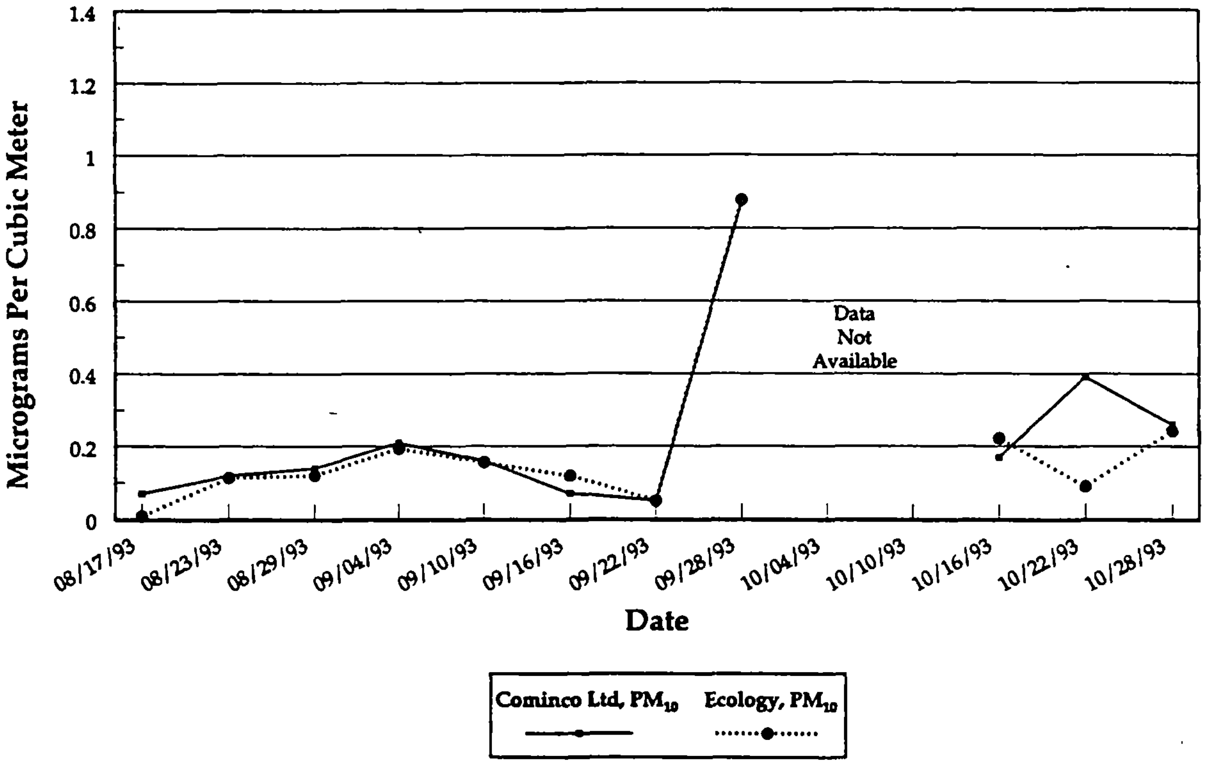
Comparison of Cominco Ltd. and Dept.of Ecology
Northport PM10 Sampling Data
Cadmium Comparison
Micrograms Per Cubic Meter
0.04
0.03
0.02
0.01
0
Data
Not
Available
08/17/93
08/23/93
08/29/93
09/04/93
09/10/93
09/16/93
09/22/93
09/28/93
10/04/93
10/10/93
10/16/93
10/22/93
10/28/93
Date
Cominco Ltd, PM10
Ecology, PM10



Comparison of Cominco Ltd. and Dept.of Ecology
Northport TSP Sampling Data
Cadmium Comparison
Micrograms Per Cubic Meter
0.04
0.03
0.02
0.01
0
Data
Not
Available
08/17/93
08/23/93
08/29/93
09/04/93
09/10/93
09/16/93
09/22/93
09/28/93
10/04/93
10/10/93
10/16/93
10/22/93
10/28/93
Date
Cominco Ltd, TSP
Ecology, TSP

Figure 6

Comparison of Cominco Ltd. and Dept.of Ecology
Northport PM10 Sampling Data
Zinc Comparison



Comparison of Cominco Ltd. and Dept.of Ecology
Northport TSP Sampling Data
Zinc Comparison

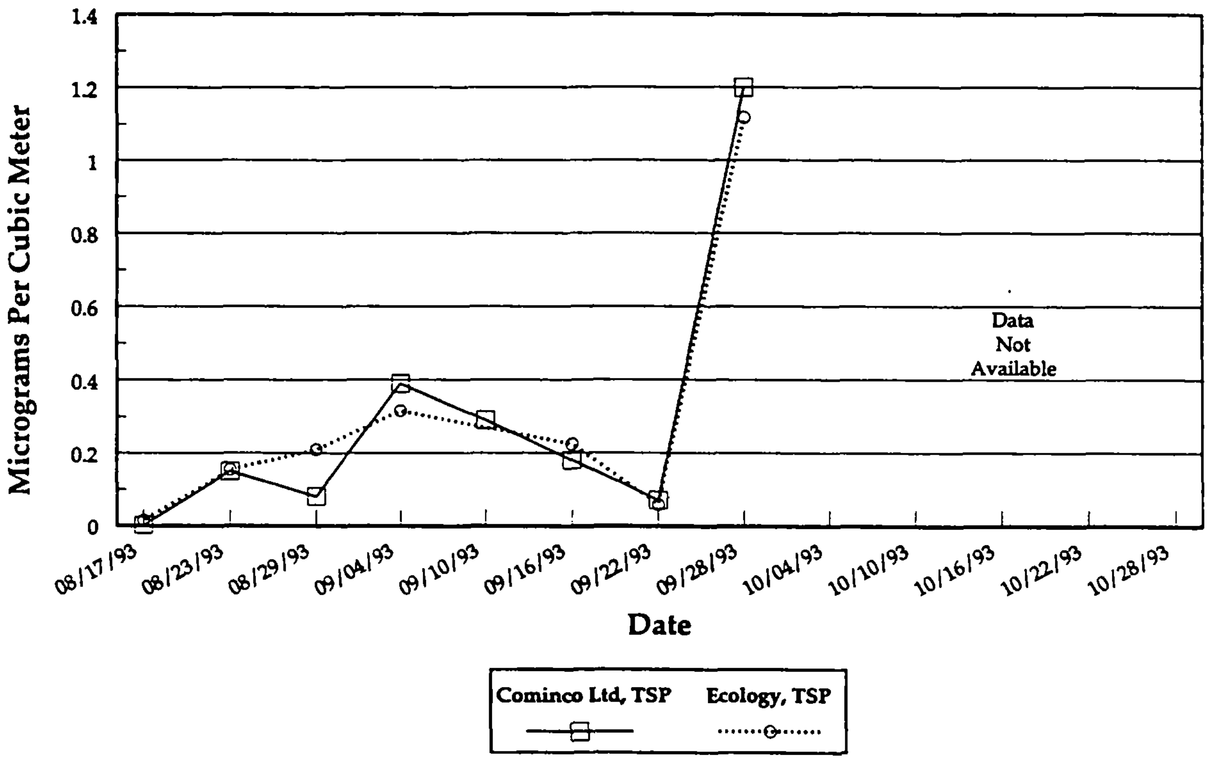


Figure 7

Wind Flow Near Northport, WA
28 September 1993

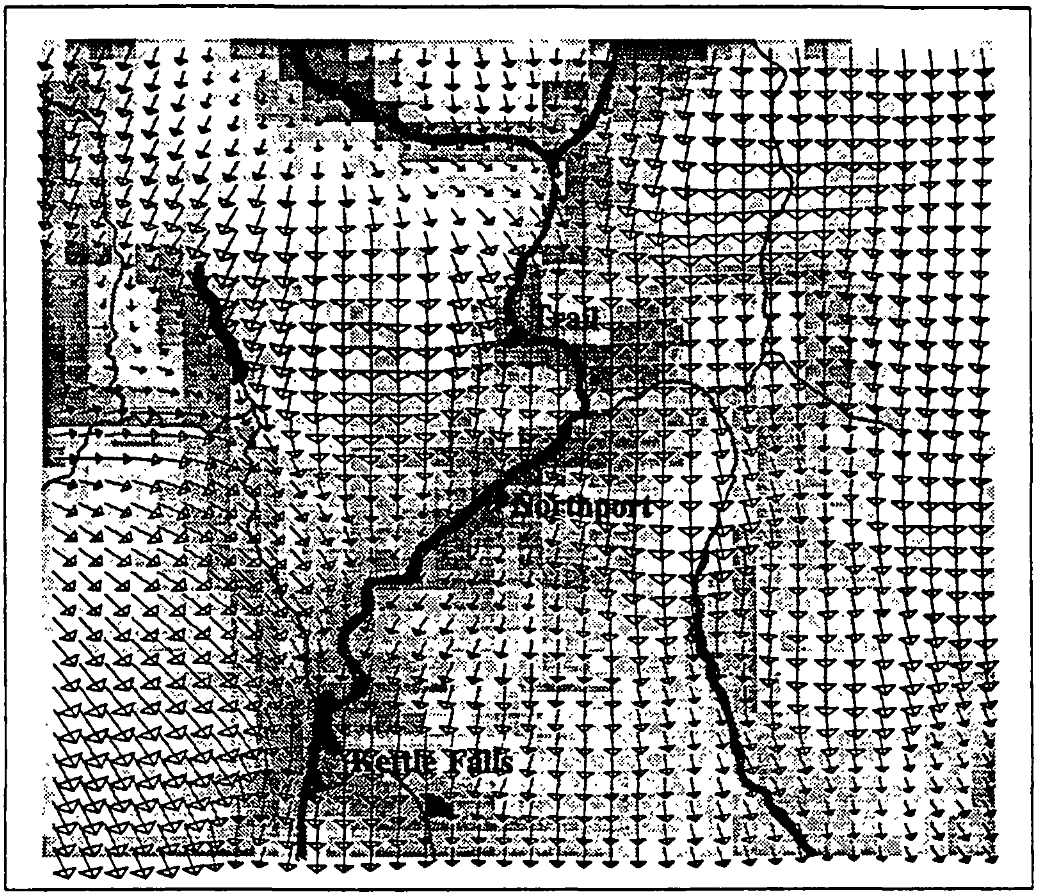


Figure 8

Figure 9

Northport Study Area

Modelled Lead Concentrations

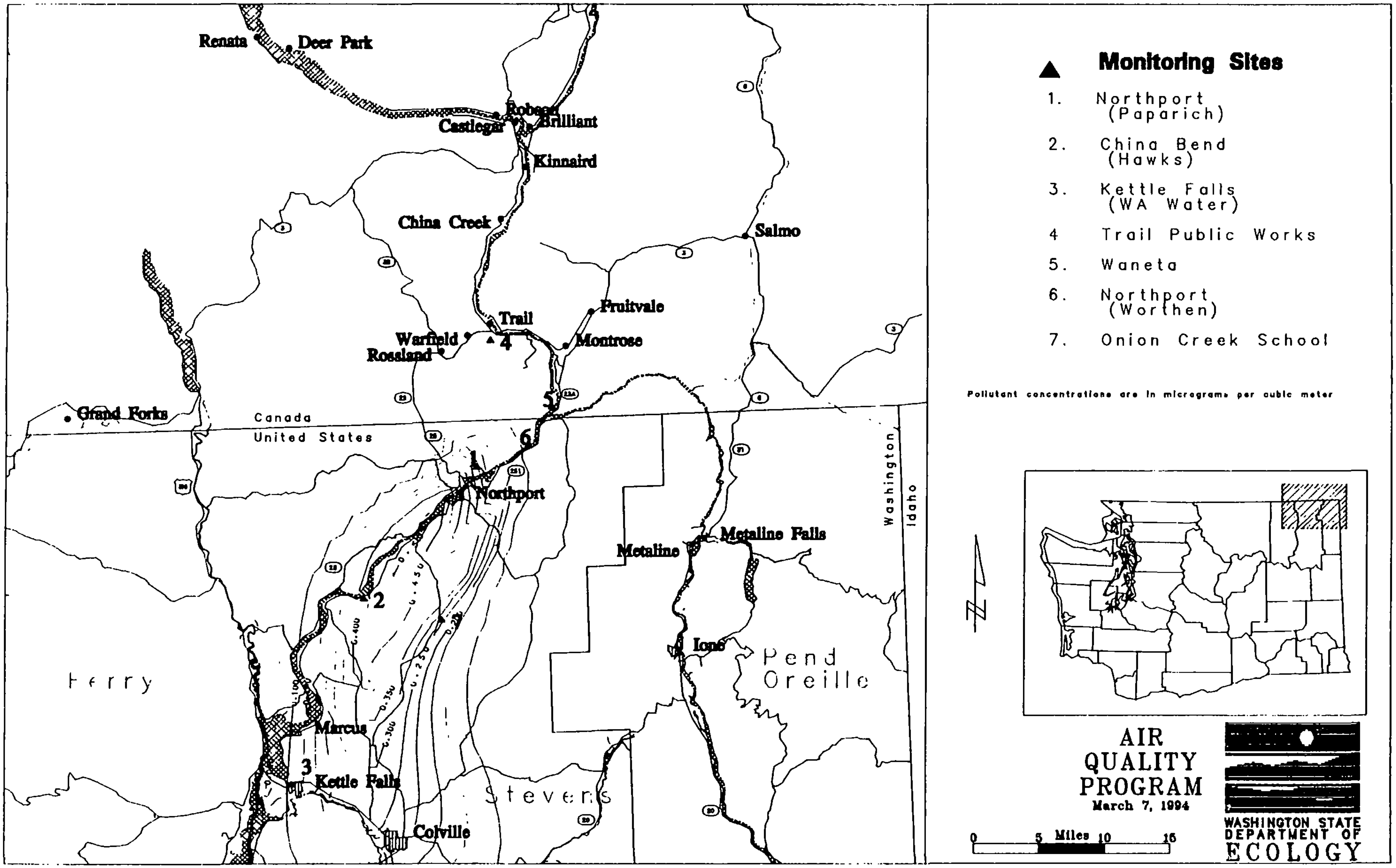


Figure 10

Northport Study Area

Modelled Cadmium Concentrations

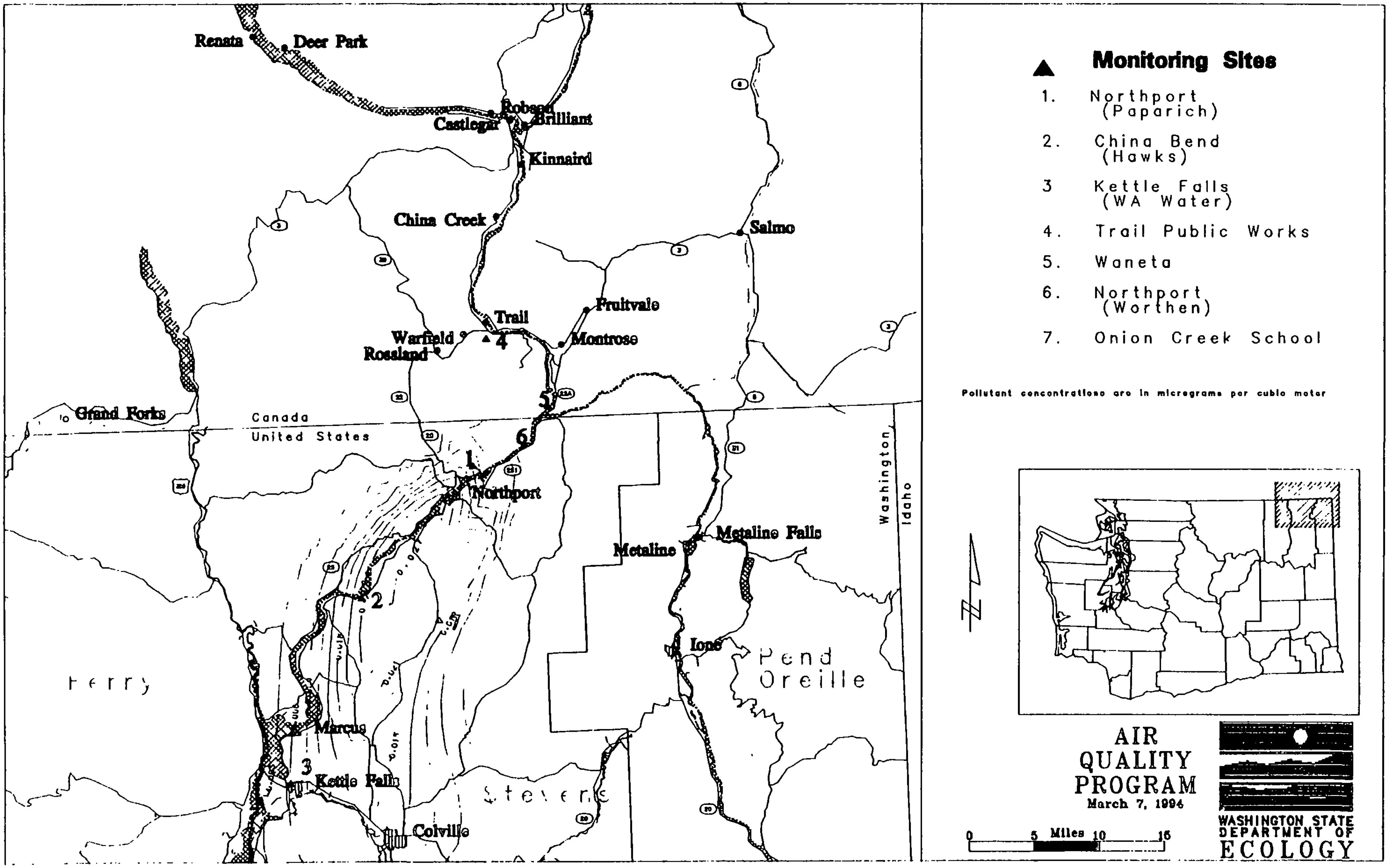
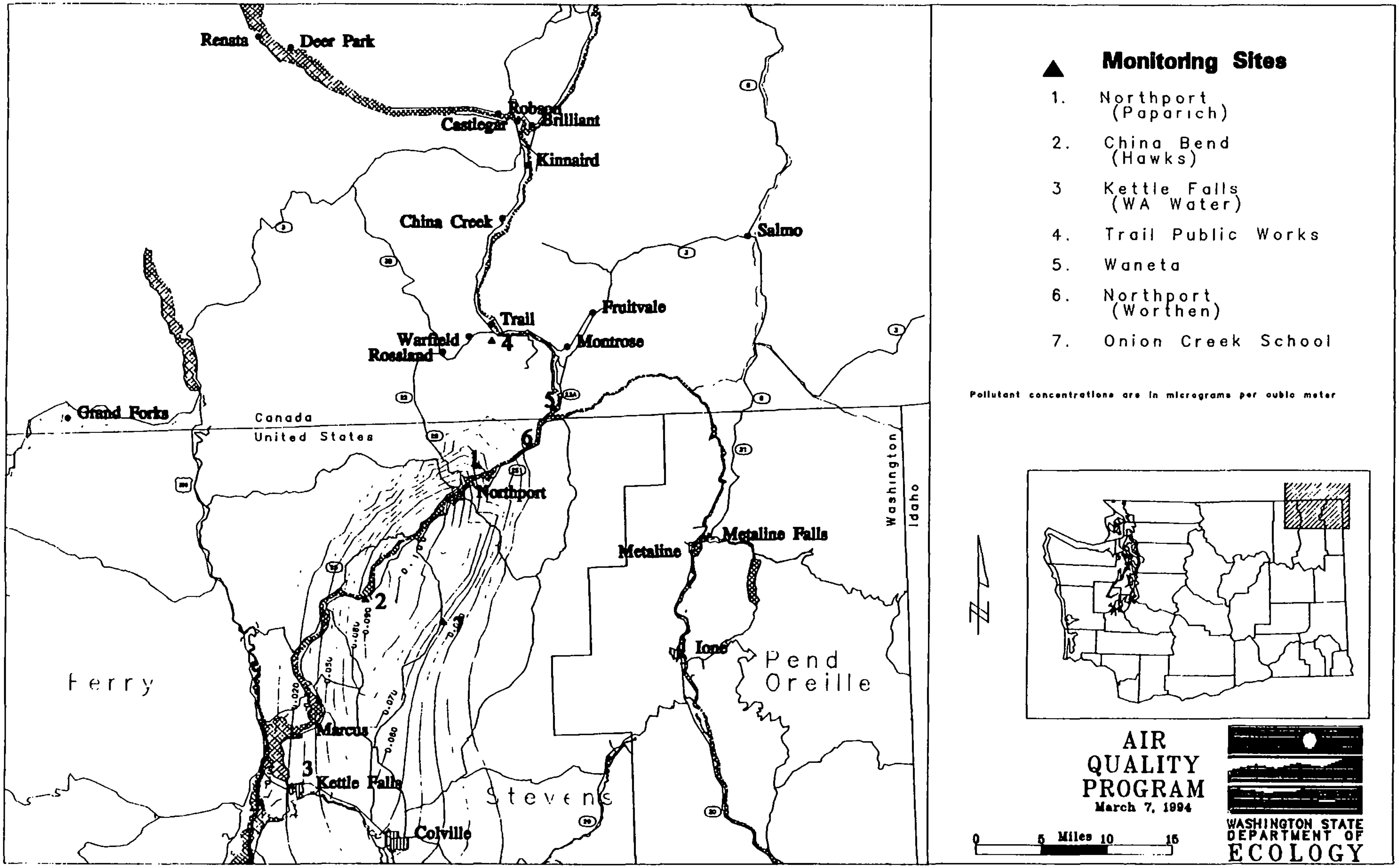


Figure 11

Northport Study Area

Modelled Arsenic Concentrations



Summary

Phase II of Ecology's air monitoring and modeling study resulted in the following findings:

- The TSP and PM10 particulate values are well within the range expected to be found within a rural community like Northport and Kettle Falls. There were no violations of either the TSP or PM10 standards.

- The analysis of the seven critical metals (cadmium, copper, zinc, antimony, lead, arsenic, and manganese) did show that only two of the metals, arsenic and cadmium, achieved levels that could require further analysis by DOH.

- Lead levels were high in comparison to monitored levels in other parts of the state, but typically were no more than one-tenth (at the Paparich site) of the existing federal and state standard.

- Comparison of Cominco, Ltd. data from Northport with Ecology's Paparich site data for cadmium, lead, zinc, and arsenic showed a good comparability and provided additional confidence that both sets of data were accurate.

- Computer wind simulation study using the CSUMM model showed that the wind conditions occurring in the study area can and do vary with height above ground. Often, when lower level winds follow the Columbia River Valley, upper level winds are blowing in an entirely different direction carrying Cominco emissions in different directions. This makes it very difficult to predict the impacts of sources of pollution within the study area.

- The air quality simulation using the MESOPUFF II model showed that pollutants from the Cominco, Ltd. smelter can, indeed, move down the Columbia River Valley and produce moderately high levels of pollutant concentrations on a 24 hour average in the study area.

Future Actions

- Ecology will continue PM10 particulate sampling at the Paparich site for one full year ending August 31, 1994.

- Ecology will perform metals analysis for lead, arsenic, zinc, and cadmium on the above Paparich data to better compare results to annual ASIL concentrations and determine any seasonal variations in metals concentrations.

- Ecology will establish and maintain a meteorological site for one year in the Northport area beginning in the summer of 1994. The meteorological station will provide local wind speed, direction, and air temperature data for an entire year. This information will be used for the above metals analysis and help refine future air quality modeling.

- Ecology will formalize an Interagency Agreement with B.C. Ministry of Environment, Lands, and Parks in the Spring of 1994. This Agreement will allow Ecology to formally participate in the development of the upcoming permit for the Cominco, Ltd. smelter at Trail, B.C.

- In the interim, Ecology will continue modeling the study area to better determine the relationship between emissions of cadmium, zinc, arsenic, and lead from various sources and local meteorological conditions and metals concentrations.

- Ecology will track and evaluate interim improvements at the Cominco, Ltd. smelter until the new permit is issued and continue evaluating the effects of these improvements on air quality in the Northport area.

PART B
HEALTH EVALUATION OF PARTICULATE AIR SAMPLES
DEPARTMENT OF HEALTH

During Phase II of their air quality study of the Northport area, Ecology collected and analyzed particulate air samples for cadmium, copper, zinc, antimony, lead, arsenic, and manganese. All except cadmium and arsenic were 1 to 10% of Ecology's ASIL values. The ASIL (Acceptable Source Impact Level) is a screening value derived from evaluation of health effect and risk, with ample safety margins, which is used to determine compliance in the source permitting process.

As a screening tool, the ASIL value can be used to determine which contaminants are of health concern. If a measured environmental sample is equal to or less than the ASIL value, the pollutant is not of concern, since by definition the ASIL is a safe exposure level. When the ASIL is exceeded, further evaluation to determine possible health impact must be done, either by the source to satisfy permitting requirements, or by DOH.

Since both cadmium and arsenic measurements exceeded the ASIL, DOH evaluated exposure concentrations further to determine their impact on human health. While lead levels were below the ASIL, the effect of lead on the nervous system of small children is of concern. The cumulative effect of lead emissions on soil lead concentration may put these children at risk. Therefore, DOH has advised the community on this contaminant metal as well.

ASILs for health effects other than cancer are based on a lifetime daily exposure over seventy years, and are expressed as "no adverse effect levels," divided by uncertainty factors ranging from 10 to 1000. They give levels of exposure at which no effect occurs, even among sensitive individuals. ASILs based on cancer risk on the other hand, use a one in one million probability of risk of cancer, which is considered a level of virtually no risk. Application of ASIL values should use chronic (long-term, such as annual) averages of population exposure to pollutants.

However, concentrations measured at the Northport sites are maximum 24-hour measurements. If sufficient measurements are taken, over several seasons, a yearly average can be calculated. In this instance, the relatively few measurements only permit a rough estimate of yearly averages. In the exposure scenario being used by DOH to evaluate health impact, the maximum daily concentrations will be used. Such evaluation overestimates the potential health impact.

LEAD

Lead was measured in the air samples collected by Ecology in Phase II (August to October 1993) at lower levels than those found during the winter of 1992-93. The amounts measured in 1994 did not exceed the National Ambient Air Quality Standard (NAAQS) for this pollutant, which requires a quarterly average of concentrations. The average value for lead over the quarter sampled was 0.1374 micrograms per cubic meter. This is less than one-tenth of the NAAQS, but compares to levels of lead measured at Harbor Island (0.1787 micrograms per cubic meter), a highly industrialized area of Seattle. Since lead was measured at higher levels during the previous winter, and since a more certain determination of quarterly averages requires on-going monitoring, additional monitoring is recommended by DOH. Ecology is continuing to monitor metals, including lead, in the Northport area over the next year.

Lead is of concern from two routes of exposure. The primary source for infants and toddlers is ingestion of soil contaminated from deposited smelter emissions or from lead in paint. A secondary route for all populations is inhalation of lead-containing particles. Because infants and toddlers are the most sensitive population, with the effect of concern being brain damage and effect on mental and physical development, the exposure from soil and air, originating with the smelter, lends importance to the lead education and blood monitoring program being conducted by NETCHD.

LEAD RECOMMENDATIONS

DOH recommends continuing air monitoring for lead, which Ecology is conducting through the next year. Monitoring of soil deposition of smelter metals is an important component of the exposure analysis that DOH is doing. EPA is conducting site analysis for selection of soil sampling. If these samples are taken and analyzed the results will be provided to DOH. Finally, NETCHD will continue its lead education and infant and toddler blood-lead monitoring project.

ARSENIC

Arsenic is a naturally occurring metal found in many kinds of rocks. Smelting of arsenic-containing ores is a common source of environmental contamination, resulting in wind-borne fine particles which can be deposited onto soil. Rain and snow leach arsenic into ground water. Additionally, arsenic can be a natural contaminant of drinking water. The major routes of exposure are by inhaling air particles containing arsenic, drinking arsenic-contaminated water, or by eating food containing arsenic. The toxicity of arsenic has made it useful as a pesticide, which has historically resulted in soil contamination in areas such as apple orchards.

Arsenic exists in many chemical forms in the environment. For example, arsenic produced from smelting operations is in one of several inorganic forms that vary in their toxicity. Arsenic from pesticides is also inorganic. Organic arsenic is the major form found in seafood. Organic forms of arsenic are much less toxic than inorganic forms.

Inorganic arsenic is absorbed well through the gastrointestinal tract and through the lung, but is only slightly absorbed through skin. Organic forms of arsenic tend to be poorly absorbed from the gastrointestinal tract. Once in the body, arsenic does not generally remain there for long (24 to 48 hours). It is excreted primarily in the urine. Arsenic is also eliminated from the body through hair and nails. Measurements of arsenic in urine, hair, and nails have been used as indicators of arsenic exposure.

Many studies have evaluated the effect of arsenic on people. Several of these studies have looked at workers, such as smelter workers or workers in pesticide-related industries, who have been exposed to arsenic at their jobs for many years. These people were exposed to arsenic levels much higher than would be expected for the general population. Additionally, studies have been done on populations that have high levels of naturally occurring arsenic in their drinking water.

Studies of arsenic-exposed populations have shown that arsenic affects many different parts of the body. In workers, inhalation of arsenic has been associated with an increased rate of lung cancer and effects on the cardiovascular system. Ingestion of elevated arsenic-contaminated drinking water has been associated with effects on the skin such as thickening of the skin, abnormal pigmentation, and cancer; cardiovascular injury resulting in diseases of the circulation system; neurological effects; gastrointestinal effects; and other cancers besides skin.

Based on the results of studies of populations exposed to high levels of arsenic, EPA has classified arsenic as a human carcinogen by both the inhalation and oral routes of exposure. EPA has calculated that a one in a million risk of developing lung cancer from inhalation of arsenic occurs at a daily exposure to a concentration of 0.0002 micrograms per cubic meter over a lifetime of seventy years. EPA has also calculated a cancer risk estimate based on a study of exposure to naturally occurring arsenic in drinking water, but arsenic in drinking water has not been found in Northport.

The following section summarizes studies of communities surrounding arsenic emitting facilities that have evaluated environmental arsenic levels and human biological measures of arsenic exposure. In addition, results of epidemiological studies of health effects in communities surrounding arsenic emitting facilities are discussed. When available, air arsenic concentrations reported in existing community studies are compared to arsenic air concentrations detected in the Northport area. In general, arsenic air concentrations detected in the Northport area are similar to levels reported in studies of communities surrounding arsenic emitting facilities. Epidemiological studies of smelter workers that have shown increased rates of lung cancer are not discussed here because the arsenic air concentrations reported in these studies are much higher than the ambient arsenic air concentrations measured in the Northport area.

Environmental arsenic concentrations have been measured in communities surrounding arsenic emitting facilities including smelters (Polissar et al., 1990; Hartwell et al.; 1983, Diaz-Barriga et al., 1993; and Landrigan et al., 1981). These studies provide measured concentrations of arsenic and, in some cases, other metals, in soil, housedust, air (indoor and outdoor), groundwater, and plant material. These studies report that the highest levels of environmental arsenic contamination were found in areas nearest the arsenic emitting source.

Arsenic air concentrations reported in these studies for locations nearest the facilities were; 0.46 micrograms per cubic meter (median, Diaz-Barriga et al., 1993), 0.0004-0.083 micrograms per cubic meter (medians, Hartwell et al., 1983), 2.5-0.03 micrograms per cubic meter (means, Landrigan et al, 1981) and 0.09 micrograms per cubic meter (mean, Polissar et al., 1990).

Arsenic soil concentrations were also reported in three of these studies for samples taken nearest to the arsenic emitting facilities; 352.5 micrograms per gram soil (mean, Polissar et al., 1990), 1.28-133 micrograms per gram soil (medians, Hartwell et al., 1983), and 1503 microgram per gram soil (mean, Diaz-Barriga et al., 1993).

One study reported low levels (median, 1.8 microgram per gram dry weight) of arsenic in homegrown fruit and vegetables from yards near a smelter (Polissar et al., 1990). Another study reported arsenic concentrations in vegetables (kale, lettuce, carrots, and potatoes) grown near an arsenic emitting wood preservation factory (Larsen, et al., 1992). Although arsenic air concentrations were not reported in this study, the authors attributed arsenic levels in vegetables, in part, to atmospheric deposition of arsenic. Arsenic vegetable concentrations reported in this study were less than 0.48 micrograms per gram (dry weight) and were the highest for kale.

Elevated levels of arsenic in urine and hair have been found in people living in these communities. Biological measurements of arsenic in urine and hair are used to determine how much arsenic people absorb into their bodies. Urinary arsenic is used to measure recent exposure to arsenic since most absorbed inorganic arsenic is excreted in the urine within 24 to 48 hours. The results of biological monitoring showed that populations, especially children, nearest the arsenic source, generally have the highest exposures. When correlations were done between measurements of arsenic exposure and environmental levels, soil was identified as a major source of arsenic exposure to children. Children put their dirty hands in their mouths, and this activity is thought to account for the relationship between soil and body arsenic levels. In these studies, arsenic air concentrations were poorly correlated to biological measures of arsenic thus appearing to be a less important source of exposure. Arsenic deposition from air, however, is a major contributor, over time, to arsenic levels in soils.

Health effects related to arsenic exposures were not evaluated in the studies discussed above. Since arsenic has been associated with lung cancer in arsenic exposed workers, health effect studies of communities near arsenic emitting facilities have focused on evaluating lung cancer rates. Studies evaluating cancer rates were conducted on adult populations since lung cancer has a long latency period and does not appear in children.

Epidemiological studies on adult populations living near arsenic emitting facilities have found small increases in rates of lung cancer, i.e. less than or equal to a two-fold increase in risk (Matanoski et al., 1981; Pershagen, 1985; Brown et al., 1984; and Cordier et al., 1983). Other epidemiological studies on similar populations have not found excess lung cancer rates (Frost et al., 1987; and Rom et al., 1982). Although children have been identified in biological monitoring studies as a highly exposed group, health effects studies on this population have not been undertaken.

Several studies that have evaluated adult lung cancer rates have also evaluated environmental measures of arsenic contamination in air and soil. Arsenic air concentrations reported in these studies are less than 0.5-1.5 micrograms per cubic meter (means, Rom et al., 1982), 0.8-0.3 micrograms per cubic meter (means, Frost et al., 1987) and mostly below 0.5 micrograms per cubic meter, with a few values exceeding 1 micrograms per cubic meter (monthly means, Pershagen, 1985). Soil arsenic concentrations nearest an arsenic emitting chemical facility were reported to be 7-695 micrograms per gram soil (maximum values, Matanoski et al., 1981) and were 70-125 micrograms per gram soil (individual samples, Brown et al., 1984) near a zinc smelter. Meteorological conditions may effect deposition and consequently the concentrations of arsenic in the soil.

A shortcoming of the epidemiological studies which evaluated cancer rates in communities surrounding arsenic emitting facilities include difficulties in quantifying arsenic exposures. In most of these studies, distance from facility was used as a surrogate for exposure. Since many of these studies involved the evaluation of death records, biological measures of arsenic exposures were not available. The contribution of other metals or other air-borne contaminants (i.e. SO_2) to the results of these studies is difficult to evaluate. Two of the studies that reported positive results only crudely adjusted for smoking habits in the population evaluated by using comparable control populations in their analysis. (Cordier et al., 1982, Matanoski et al., 1981). Two other studies which showed increased rates of lung cancer, however, adjusted for smoking on an individual basis using a case-control study format (Pershagen, 1985, Brown et al., 1984).

Arsenic Recommendations

The arsenic air concentrations detected in the Northport area (Phase I maxima 0.02 - 0.25 micrograms per cubic meter; Phase II maxima 0.03 - 0.11 micrograms per cubic meter) are similar to arsenic air concentrations reported in studies of communities surrounding arsenic emitting facilities. In order to be able to better compare the Northport area to the results of existing studies, environmental arsenic concentrations in soil and other media as well as biological measurements of arsenic exposure should be collected. Children may be of special concern for exposures to arsenic in the Northport area, especially from ingestion of soil. The health significance of children's chronic exposure to environmental arsenic, however, is not known but may involve the nervous and cardiovascular systems (Diaz-Barriga et al., 1993).

Cadmium

Cadmium is a metal that is an important environmental pollutant in industrialized countries. For the general population the main sources of exposure are diet (from contaminated drinking water and from crops grown on contaminated soil) and tobacco smoking. For people living in the vicinity of smelters, breathing fine particles containing cadmium can be a significant route of exposure.

Cadmium is a cumulative poison that remains in the body. It mainly accumulates in the kidney. When it reaches a critical level, it causes damage that interferes with kidney function. Such damage can be detected through the appearance of a small protein in the urine, which is not found in the urine of unaffected people. The kidney damaged by cadmium can also excrete calcium in excessive amounts, leading to a loss of bone mass, which is called osteomalacia.

Because cadmium accumulates in the kidney over time, the concentration increases with age. Women reach a critical body burden more readily than men, and diabetics may suffer kidney damage at a lower kidney concentration of cadmium than other members of the population. (Body burden is the total accumulation of the contaminant from all exposure routes, ingestion, inhalation and dermal, where applicable. With continuing exposure, the body burden can reach harmful concentrations). Smoking tends to double an individual's kidney burden of cadmium that is already accumulating from dietary, or other inhalation sources.

Many studies of the critical level of cadmium have been done among workers exposed through their occupation. For such workers, who tend to be healthy young men, the concentration of cadmium by age 50, which causes measurable signs of kidney damage, has been determined to be 200 micrograms cadmium per gram, kidney cortex tissue (wet weight). The general population includes members who may be susceptible to the effects of cadmium due to their age, sex, size, state of health, or genetic predisposition. For instance, kidney disease or diabetes, or being female, causes individuals to suffer kidney damage at lower kidney cadmium concentrations than healthy young male workers. More recent studies done on the general population, indicate that a critical level, which would reflect kidney damage to more sensitive members, is 50 micrograms cadmium per gram kidney cortex tissue (wet weight).

In addition to its effect on the kidney, cadmium has a probable human cancer risk, as determined by EPA. This determination is based on limited evidence in occupational epidemiological studies of lung cancer occurrence, and sufficient evidence of lung cancer in animals exposed to cadmium via inhalation. One in a million risk of developing lung cancer, as calculated by EPA, occurs at a chronic inhalation concentration of 0.006 micrograms per cubic meter over a seventy year lifetime exposure. The cancer risk projection is based on the assumption that there is no exposure concentration threshold. Cadmium has been implicated in cancer of the prostate, and other soft tissue cancers, but no significant associations with these malignancies have been established through epidemiological studies.

Inhalation exposure of workers in cadmium-related industries to cadmium-containing fumes, dusts, and pigments has resulted in pulmonary disease such as emphysema and bronchitis, after several years of exposure to high levels (in the 100 milligram per cubic meter range). While hypertension has been demonstrated in animals chronically exposed to cadmium in diet, no conclusive evidence exists that cadmium has a role in the development of human hypertension. Effects on the blood-forming capacity, such as iron deficiency anemia, have been noted in humans, among workers exposed to high levels. Since this metal does not readily cross the placental barrier, no developmental effects would be expected, and none have been observed in humans.

Kidney dysfunction and its consequences, induced by accumulation of cadmium, is essentially irreversible. There is no medical treatment that can prevent the accumulation of cadmium in the kidney, nor is there a way to reduce the amount of cadmium, or to eliminate it, once it is stored in the kidney. Minimization of exposure is the only available approach for averting the adverse effects of cadmium.

Cadmium can cause severe irritation, with resulting inflammation, of the gastrointestinal tract. An occupational study has indicated that there may be a weak association between mortality from non-malignant gastrointestinal disease (NMGID) and cadmium exposure. While the link is tenuous, cadmium needs to be ruled out or established as an agent in such illness because the Northport area does have a higher incidence of inflammatory bowel/Crohn's disease. The inference for a link was derived from a study that had a very much higher level of exposure to cadmium than that measured in the air in Northport. At present it is not known whether inhalation exposure to levels of cadmium in Northport plays a role in NMGID.

DOH reviewed the air monitoring data provided by Ecology, to assess exposure of the population in the Northport area to cadmium, and to evaluate possible health impact. Evaluating the health effect from environmental exposure to cadmium requires determination of the additional burden that it adds to the cadmium that is already accumulating from one's diet. Cadmium intake from air pollution is usually small for individuals living in non-polluted areas, compared to that from food and smoking. However, significant exposure can occur in areas surrounding cadmium-emitting industries.

In order to determine how much the cadmium in outdoor air adds to the total body burden, and to the kidney burden, it is important to estimate a "normal" body burden derived from one's diet. For non-industrially-exposed nonsmokers, food is the major source of cadmium exposure.

Studies conducted on workers and residents in communities near cadmium-emitting facilities have demonstrated that cadmium essentially remains in the body for a lifetime. Because only very small amounts are eliminated from the body, it accumulates continually from birth on. Cadmium does not readily cross the placenta, so that fetuses are not exposed before birth. As cadmium enters the body, it is absorbed to varying degrees, depending on route of entry. From the gastrointestinal tract, about 4 to 7% is absorbed into the blood. Absorption depends on factors such as the sex of the individual, and nutritional status. Women and those with anemia or iron, calcium or Vitamin D, or protein deficiency will absorb greater amounts through the gastrointestinal tract. Up to 10% can be absorbed by those with nutritional deficiencies.

Once absorbed, cadmium is distributed to various organs including the liver, and from there moves to the kidney, where about one-third of the total body burden accumulates. Sensitive individuals may begin to experience damage when the concentration of cadmium in the kidney cortex reaches about 50 micrograms cadmium per gram kidney cortex tissue. Damage can be measured by the appearance of a small protein (urinary ß-2 microglobulin) in the urine. The level of cadmium in the urine is an index of exposure. When the amount excreted exceeds 2 micrograms/day, it correlates with the level of damage.

The amount added to the body burden (and to the kidney cortex) by the diet thus varies through the population according to individual sensitivity. The amount also varies by the amount of cadmium found in food, primarily that found in leaf and root crops, and from grain.

EPA surveyed United States and world soil data for metals and found that the usual range for cadmium levels in soil was from 0.01 to 0.70 micrograms per gram (Carey and Barrett, 1980). Alloway (1990), however, reported cadmium concentrations in United States agricultural soils ranged from 0.005 to 2.4 micrograms per gram, with a mean of 0.27 micrograms per gram. He also reported that soils in lead-zinc mining areas in the United Kingdom contained cadmium concentrations up to 540 micrograms per gram and up to 750 micrograms per gram in the vicinity of a zinc smelter in Montana (Alloway, 1990). Unidentified references have found United States native soil cadmium concentrations to range from 0.01 to 45 micrograms per gram, and inorganic and organic surface soils in the state of Washington to have mean cadmium values of 0.190 and 0.420 micrograms per gram, respectively.

The village of Shipham in Somerset, United Kingdom, was the center of zinc mining activity from the 17th to the 19th century. Much of the housing is built upon the sites of the old mines. Agricultural and garden soils in the contaminated areas contained cadmium at concentrations ranging from 2 to 360 micrograms per gram, with a median value of 90 micrograms per gram. For uncontaminated soils in the United Kingdom, by comparison, the range and median were 0.08 to 10 micrograms per gram and less than 1 micrograms per gram. Crop samples were collected and analyzed for heavy metals. The average concentration of cadmium was 0.25 micrograms per gram. The average value for the same crops in the United Kingdom was 0.015 micrograms per gram. The most contaminated vegetables contained cadmium 15 to 60 times greater than for crops grown in ordinary soils. Crops that contained higher than normal concentration of cadmium were leafy vegetables and root crops. Tomatoes, beans, and peas were relatively unaffected (Morgan and Simms, 1988). This differential uptake of cadmium by crop species is similar to that reported by Alloway (1990) in his review.

In 1993, EPA sampled soil from the Northport LeRoi smelter site, and three offsite stations, which were the Northport city park and two areas upstream from the smelter site. Estimated onsite cadmium concentration ranged from 11.6 to 26.8 micrograms per gram. Estimated offsite concentrations ranged from 0.72 to 8.16 micrograms per gram (U.S. EPA, 1993). The soil concentrations at the LeRoi smelter site are less than one tenth of those reported from the United Kingdom and Montana. The offsite (background) concentrations are within the range reported for the United States, and greater than those reported for typical surface soils in Washington State. No comprehensive data are available for residential garden crops and soils in Northport and the surrounding urban area.

This spring, EPA is evaluating whether additional soil sampling for heavy metals analyses will be conducted in the Northport area.

EXPOSURE PARAMETERS FOR DOH EVALUATION OF CADMIUM

In order to establish body burdens accumulated for a 50-year exposure, DOH used the average daily intake of cadmium in the United States, derived from a number of studies. This average daily intake is 75 micrograms of cadmium. The gastrointestinal absorption rate chosen by DOH was 10%, which is that found among sensitive individuals. Ten percent of the average daily intake is 7.5 micrograms per day uptake, and is the uptake rate used by DOH in its calculations.

Cadmium remains in the body virtually for a lifetime, but a half-life of 19 years (after which one half of the original cadmium taken up would have left the body), amounts to an excretion rate of 0.01 micrograms per day. DOH used an exposure duration of 50 years, with an excretion rate of 0.01 microgram for each day during the 50 years.

To determine how much cadmium is found in the cortex relative to the medulla of the kidney, DOH used the normal weight ratio of cortex/medulla of 1.5, and a total kidney weight of 300 grams (which is the average adult kidney weight).

In order to use the concentration of cadmium in the kidney cortex at which a sensitive individual would begin to experience damage (the critical concentration for such a person), DOH used 50 micrograms per gram, renal cortex tissue concentration.

To calculate inhalation exposure, DOH used an adult inhalation rate of 20 cubic meters per day air, with a 25% absorption rate for cadmium. This absorption rate has been derived from a number of studies.

In preparing its health statement on cadmium exposure, DOH chose the maximum concentration (0.0474 micrograms per cubic meter) measured in Phase II of the study (See Table IV of Ecology's report). Cadmium levels were not quantified in Phase I of the study, but in examining Phase II data, cadmium and lead correlate very well over this period measured. Since the two metals are being emitted from the same source, it is possible to estimate the cadmium levels that existed during the Phase I period using the lead to cadmium correlation observed in the Phase II data. This calculation results in an average estimated cadmium value that is approximately equal to the maximum value measured in Phase II.

This value (0.0470 micrograms per cubic meter) is used so as to not underestimate the potential health problem, but with the realization that it may overestimate the impact. Since the health effects that are being considered result from long-term exposure, and thus usually are based on yearly averages, and since the ASIL values are based on yearly averages, the value chosen by DOH may overestimate exposure, but was chosen to ensure a protective evaluation.

The yearly average cadmium levels to which people in the area are exposed may be considerably less than the value DOH is using. It may be useful to put these numbers in perspective by comparing them to average ambient cadmium concentrations found in other parts of the country. The following table contains annual average concentrations for cadmium found in various urban and nonurban settings, and the range of levels found in Northport.

Location	**Date**	**Cadmium Concentration Micrograms Per Cubic Meter (annual averages)**
Northport area	1992-93	0.0474 (highest reading)
El Paso, TX	1969	0.12
New York City, NY	1969	0.014
San Francisco, CA	1969	0.006
St. Louis, MO	1969	0.036
29 nonurban locations	1969	<0.003
Bronx, NY	1970	0.014
Manhattan, NY	1970	0.023
Poland (ten cities)	1971	0.002 to 0.05
Cincinnati-urban	1972	0.0032 to 0.0034
Cincinnati-suburban	1972	0.0017 to 0.0021
Tokyo, Japan	1969-72	0.01 to 0.053 (0.53 max.

It should be noted that with the exception of the Northport measurements, these concentrations were measured in the late 1960s, and early 1970s before air pollution regulations went into effect. More recent data show average levels of cadmium in ambient air ranging from less than 0.006 micrograms per cubic meters in remote areas, to 0.040 micrograms per cubic meter in urban area, and up to micrograms per cubic meter in industrialized areas. Cadmium concentrations in the United States and elsewhere have been increasing in recent years.

Several studies have been conducted on the effect of smoking on cadmium exposure. Tobacco products contain cadmium, of which 25% is absorbed by the lungs. A person who smokes 1-2 packs per day doubles the cadmium burden of the renal cortex over time.

DOH used an equation to calculate the amount of cadmium that a sensitive individual living in the Northport area might accumulate at 50 years of age, after having been exposed to the air in this community every day of that period, and who at the same time was getting cadmium exposure from food. The details of this calculation can be found in the Appendix F.

From this calculation, the renal cortex concentration from dietary intake alone is:

42 micrograms of cadmium per gram of kidney cortex wet weight

and the amount accumulated from breathing the ambient air is added, the concentration becomes:

43.3 micrograms of cadmium per gram of kidney cortex wet weight

This value is below the critical kidney cortex concentration at which damage occurs in sensitive individual, but there is very little margin of safety in this level. Smoking doubles the burden of cadmium in the kidney cortex. For sensitive individuals, this becomes:

86.6 micrograms of cadmium per gram of kidney cortex wet weight

which is considerably above the 50 micrograms of cadmium per gram kidney cortex at which damage has been shown to occur in sensitive individuals.

Summary Of Recommendations For Metals

Lead

Lead continues to be of concern because of multiple sources of exposure, including that which has been measured in air.

Prevention of exposure from all routes of entry is the best way of preventing lead poisoning. For children, eating dust and soil containing lead is the largest source. Eating may involve simply sticking dirty hands in the mouth. Not allowing contact with dust or soil contaminated from chalking and flaking paint, and smelter dust-contaminated-soil is the best way to avoid exposure. This can be accomplished through damp cleaning in homes, hand washing, and keeping contaminated soil covered with grass, clean dirt, cement, or asphalt. Washing of home-grown vegetables to remove dust also reduces exposure. Monitoring of lead in blood is the best way of detecting when exposure has occurred.

Arsenic

Contact with arsenic-contaminated soil also provides exposure to children when they put dirty hands in their mouths. This adds to that which is being breathed. The same recommendations for prevention of such exposure to children that were given for lead hold for arsenic. As with lead, washing of home-grown vegetables is also recommended.

Air exposure and soil deposition from smelter emissions need to be reduced. At present, it is not known whether significant levels of arsenic are present in Northport soils, but such information should be available soon and will be communicated to the community.

CADMIUM

Because cadmium stays in the body once it enters by any route, DOH recommends that citizens of Northport avoid exposure where possible. There is exposure from the air being breathed, and this cadmium is derived from smelter emissions. It also falls as particulate deposition on the soil in the area. At present, EPA is considering measuring soil concentrations, but as yet results are not known. It is, therefore, not known whether concentrations in plants are sufficiently high to warrant concern. In addition, leafy vegetables and fruits may have some dust on their surfaces.

To reduce ingestion of cadmium and other heavy metals from airborne and soil contamination, locally-grown crops should be washed before eating. If soil levels are found to be of concern, information on how to deal with this will be promptly provided by NETCHD and DOH.

Since the greatest single exposure to cadmium comes from cigarettes or other tobacco smoke, DOH recommends that citizens do not smoke. Smoking can double the kidney cortex burden, so that the renal cortex concentration for dietary and ambient air intake plus cigarette smoking would be 86.6 micrograms per gram, well above the critical value for sensitive persons. Smoking also causes respiratory, cardiovascular, and cancer risk and should be avoided.

Children should wash their hands before eating. They should also avoid playing on areas of bare soil. Play areas can be covered with grass or other ground covers to reduce contact with soil that can be taken into the mouth, and prevent the release of dust into the air.

It may be useful for those patients who have had diagnoses of Crohn's disease or inflammatory bowel disease to have their physicians evaluate their urine for cadmium levels. While any role for cadmium in these disorders has not been investigated, there is a slight indication that its role as a gastrointestinal irritant might have some part in the development of gastrointestinal illnesses.

11. ***Obtain Manganese blood and urine data from the Spokane area physician and assess the need for additional testing.***

ELEVATED MANGANESE

In response to residents' concerns over elevated levels of manganese detected in blood and urine samples, DOH is investigating the potential health effects from environmental exposures in the Kettle Falls area. Several potential sources of environmental exposure to manganese have been preliminarily identified, including well water, soil, and dust and occupational exposure to ash. These environmental sources may potentially result in one or more distinct routes of exposure to humans, including oral, inhalation and dermal routes. In July of 1992, Ecology, NETCHD, and DOH developed a work plan to address this issue of manganese in the Kettle Falls area.

Records of blood and urine manganese levels from citizens who were concerned with manganese toxicity were obtained from several physicians. These records included five medical charts from residents of Kettle Falls who identified themselves as having manganese toxicity. Additionally, symptom checklist and laboratory results were obtained from a Spokane area physician on 28 individuals who had potential exposure to manganese at their workplace. These medical records and laboratory results were reviewed by a toxicologist and a physician. A summary of their conclusions are discussed under the *Medical Records Review Section* (page 26).

In addition to the review of medical records by DOH, the work plan also specified that:

- NETCHD would obtain and review stack emission and ash data from the Boise Cascade plywood plant and the Washington Water Power Plant;

- Ecology would conduct air monitoring in Kettle Falls for manganese, cadmium, copper, zinc, lead, arsenic, and antimony;

- DOH would obtain and review the National Institute of Occupational Safety and Health (NIOSH) report on manganese at the Boise Cascade plant; and,

- NETCHD would share data on drinking water manganese levels found in city and private wells with Ecology and DOH.

Manganese In The Kettle Falls Area

Manganese is a naturally occurring substance found in many types of rock. It is usually combined with other chemicals such as oxygen, sulfur, and chlorine. Small particles of these compounds may become suspended in the air or become dissolved in water, both of which may result in human exposure. The northeast section of Washington State typically contains rocks high in manganese compounds. Because manganese is a natural component in the environment, people are continually exposed to low levels of it in water, air, soil, and food. Anthropogenic activities such as mining, the production of manganese ores, or other industrial processes, may also increase one's exposure to manganese from the air or water. A person's total exposure to manganese is from some combination of these sources.

Some residents of the Kettle Falls area have been concerned about elevated levels of manganese in blood and urine and the health problems associated with environmental exposure to manganese. Several residents attributed their health problems to the industrial discharges to the air and water from industries located in the vicinity. Health problems reported include muscle pain and cramps, difficulty in speech and gait, and numbness. Concern was expressed by a physician who tested employees at a local industry who had slightly elevated urine manganese levels.

Manganese Toxicity

Manganese is an essential trace element in humans. This means that the body requires it in very small amounts. Too much manganese, however, can cause serious illness. Humans exposed to manganese dust in mines and factories can develop serious and ultimately disabling neurologic dysfunction. The disease, termed manganism, may initially result in transient psychomotor disturbances such as hallucinations, emotional instability, and compulsive and aberrant behavior. As the disease progresses, a Parkinsonian syndrome may develop, marked by weakness, sluggishness, rigidity, and tremor. Manganism occurs because too much manganese injures a part of the brain that helps control body movements. The symptoms of this disease are treatable with various drugs. However, brain injury is believed to be permanent.

There is a well-documented association of prolonged inhalation of manganese dusts with psychological and neurological disorders. However, there is very little information regarding manganese poisoning through ingestion of water. One retrospective drinking water study (1 to 2 months exposure) in Japan identified 16 cases of manganese poisoning. The symptoms included lethargy, increased muscle tonus, tremor and mental disturbances. Children were less affected than adults. The concentration of manganese in the water was estimated to be approximately 28 milligrams per liter. An epidemiologic drinking water study (persons 50 years and older) in Greece indicated that increases in manganese concentrations were associated with an increasing trend in the neurological signs of chronic manganese poisoning. The concentration of manganese in the water from this study ranged from 0.0036 milligrams per liter to 2.3 milligrams per liter, with significant effects seen at the higher level. Even though both of the studies had weaknesses, they do raise some questions about acceptable levels of manganese in drinking water and the bioavailability of manganese from water.

Drinking Water And Dietary Information

At the present time EPA and Washington State drinking water standards list manganese as secondary contaminant regulated at 0.05 milligrams per liter. In the Final Draft of the Drinking Water Criteria Document for Manganese (1991), a reference dose (RfD) of 100 microgram per kilogram per day was used to calculate a safe dose that children could be exposed to for 1 to 10 days, and a Longer-Term Health Advisory of 0.2 milligram per liter. As yet, a maximum contaminant level (MCL) for manganese in drinking water has not been proposed in the Federal Register. Once an MCL standard is proposed, it generally takes 18 months for the public review process before a standard becomes final and written into the Federal Register. It is likely that once a primary MCL is proposed, it will be under 1 milligram per liter, possibly in the vicinity of 0.2 milligram per liter.

The National Academy of Science recommends a dietary allowance of 2.5 to 5 milligram of manganese per day. EPA has calculated a dietary concentration which is believed to result in no adverse health effect (No Observed Adverse Effect Level - NOAEL) of 10 milligram per day for chronic human consumption of manganese from food. Foods of plant origin are generally high in manganese, while meats, seafood, and dairy products are low.

Preliminary environmental sampling from a private well in Kettle Falls was conducted by DOH in June of 1990, and indicated water manganese levels greater than 8 milligram per liter. Additional sampling of water and soil have been taken and are to be analyzed. NETCHD is studying the feasibility of a sampling program to evaluate the current findings.

Medical Records Review

DOH reviewed the medical or laboratory records for 32 people in the Kettle Falls area for manganese toxicity. Twenty-eight of these people were screened by a physician to determine possible occupational exposure to manganese and related health effects. These individuals had a single screening for urine and blood manganese levels. They were also given a symptom questionnaire. Five people submitted individual medical records. Since one person submitted both medical records and laboratory results from the screening program, he total number of individuals was 32.

Of the 28 people in the occupational group, 21 had slightly elevated urine manganese levels. Two of these people also had slightly elevated blood manganese levels. Some of the people had various symptoms, such as cramps, stiffness, fatigue, and poor memory. While these symptoms are associated with manganese poisoning, they are also symptoms of other conditions and are not specific to manganism. With the exception of one individual with fine motor tremor of one hand, the physical examinations were normal.

Of the five people who submitted individual medical records, three did not have physician diagnoses of manganism. Of the three, one had slightly elevated urine manganese levels and another had slightly elevated serum manganese levels. Two individuals were diagnosed by a physician as having Parkinson's disease as a result of manganese poisoning. These individuals had elevated levels of manganese in their blood and urine as well as clinical symptoms of manganism. One of these individuals had a neurological examination, which did not corroborate a diagnosis of manganism. However, neurological examination may not provide a definitive diagnosis for this condition.

Manganese Conclusions

Biological evidence has shown that high levels of manganese exposure can cause adverse human health effects. The principal concern associated with manganese exposure is its neurotoxic effects on the brain. It is believed that this neurotoxicity is caused by the depletion of dopamine. Dopamine is a normal substance secreted by certain cells in the brain to control precise movements. When dopamine is depleted additional neurotoxins are produced.

The association between exposure to high levels of manganese in the air and dust and adverse human health effects has been well documented. DOH is aware of only two studies that investigated health effects associated with manganese in drinking water. Besides exposure to manganese, other factors need to be considered in evaluating potential health effects. This would include individual susceptibility to manganese poisoning, an accepted clinical feature of manganese toxicity. Blood and urine manganese levels are important, but not diagnostic. Manganese levels measured in these media may indicate an average level or range of exposure on a group basis, but are not specific on an individual basis. High levels of manganese may be found in the blood and urine of unaffected persons; and a normal range maybe found in affected persons, because these levels merely reflect recent or current exposure. Studies to date do not show a dose-response relationship for urine manganese and health disorders. Additionally, synergism with other elements may influence the toxicity of manganese.

Given the lack of adequate environmental data from both air and water sources, DOH is unable to conclude at this time a direct cause and effect relationship associated with manganese exposure in the Kettle Falls area. This is not to say that adverse health effects are not resulting from exposure to manganese from this area. Given the lack of adequate environmental data, DOH will evaluate possibility of additional environmental sampling once it becomes available to better characterize possible exposure to manganese and make appropriate recommendations based on these findings.

REFERENCES

A.E. Carey and E.L.R. Barrett, Metals in Soils - A Brief Summary, U.S. EPA, Memorandum dated November 17, 1980

B.J. Alloway, Cadmium, Heavy Metals in Soils, John Wiley and Sons, 1990

H. Morgan and D.L. Simms, *The Science of the Total Environment*, 75, (1988) 135-143

U.S. EPA, LeRoi Company Smelter Site Inspection Report, Contract No. 68-W9-0054, Work Assignment No. 54-17-OJZZ, ARCS,

Pershagen, G. *Lung Cancer Mortality Among Men Living Near an Arsenic-Emitting Smelter.* American Journal of Epidemiology 1985;122:684-693.

Matanoski, G. M., Landau, E., Tonascia, J., Lazar, C., Elliott, E. A., McEnroe, W., and K. King. *Cancer Mortality in an Industrial Area of Baltimore.* Environmental Research 1981;25:8-28.

Frost, F., Harter, L., Milham, S., Royce, R., Smith, A. H., Hartley, J., and P. Enterline. *Lung Cancer among Women Residing Close to an Arsenic Emitting Copper Smelter.* Archives of Environmental Health 1987;42:148-152.

Cordier, S., Theriault, G., and H. Iturra. *Mortality Patterns in a Population Living near a Copper Smelter.* Environmental Research 1983;31:311-322.

Brown, L. M., Pottern, L. M., and W. J. Blot. *Lung Cancer in Relation to Environmental Pollutants Emitted from Industrial Sources.* Environmental Research 1984;34:250-261.

Díaz-Barriga, F., Santos, M. A., Mejía, J., Batres, L., Yáñez, L., Carrizales, L., Vera, E., del Razo, L. M., and M. E. Cebrián. *Arsenic and Cadmium Exposure in Children Living Near a Smelter Complex in San Luir Potosi, Mexico.* Environmental Research 1993;62:242-250.

Landrigan, P. J. and E. L. Baker. *Exposure of Children to Heavy Metals from Smelters: Epidemiology and Toxic Consequences.* Environmental Research 1981;25:204-224.

Hartwell, T. D., Handy, R. W., Harris, B. S., Williams, S. R., and S. H. Gehlbach. *Heavy Metal Exposure in Populations Living around Zinc and Copper Smelters* 1983;38:284-295.

Rom, W. N., Varley, G., Lyon, J. L., and S. Shopkow. *Lung Cancer Mortality Among Residents Living Near the El Paso Smelter.* British Journal of Industrial Medicine 1982;39:269-272.

Enterline, P. E., Henderson, V. L., and G. M. Marsh. *Exposure to Arsenic and Respiratory Cancer: A Reanalysis*. American Journal of Epidemiology 1987;125:929-938.

Polissar, L., Lowry-Cable, K., Kalman, D. A., Hughes, J. P., van Belle, G., Covert, D. S., Burbacher, T. M., Bolgiano, D., and N. K. Mottet. *Pathways of Human Exposure to Arsenic in a Community Surrounding a Copper Smelter*. Environmental Research 1990;53:29-47.

Larsen, E. H., Moseholm, L. and M. M. Nielsen. *Atmospheric Deposition of Trace Elements Around Point Sources and Human Health Risk Assessment. II: Uptake of Arsenic and Chromium by Vegetables Grown Near a Wood Preservation Factory*. The Science of the Total Environment 1992; 126:263-275.

EPA. Health Assessment Document for Inorganic Arsenic. 1984, EPA-600/8-83-021F.

ATSDR. Toxicological Profile for Arsenic, 1993. EPA Region 10, October 15, 1993.

Appendices

Appendix A

Methodology

The following methodology was used to derive estimates of the expected number of cancer deaths in the Northport area:

Comparison to U.S.

1. The number of people in a specific age group living in the incorporated town of Northport (1990, U.S. Census Bureau) was multiplied by the United States mortality rate (National Center for Health Statistics, *Advance Report of Final Mortality Statistics, 1990,* Vol 41(7), January 7, 1993) for that age group to arrive at the expected number of deaths for each group. The following age groups were used: less than 1 year, 1 to 4 years, 10-year age groups through age 84 (i.e., 5-14, 15-24,etc.), and greater than 84 years.

2. The expected number of deaths for each age group was summed to arrive at the total number of expected cancer deaths for 1990.

3. The total was multiplied by 2 to account for an equal number of "Northport" residents living in the unincorporated area surrounding Northport.

4. The number from step 3 was multiplied by 20 to be comparable to the 20-year period covered in the reports from Northport.

Comparison to Washington State

The identical procedure was employed except that the 15 to 24 year old age group was divided into 15-19 years and 20-24 years. The expected numbers for each age group was calculated separately for females and males. Washington State mortality rates were from the Washington State Department of Health, *Annual Summary of Vital Statistics 1991*, published in October 1992.

Tests of statistical significance were conducted by developing a confidence interval around the 32 observed cancer deaths. The normal approximation to the binomial distribution was used following the methodology of Fleiss, J. *Statistical Methods for Rates and Proportions*, 1981. The lower ninety-five percent confidence intervals for the 32 observed deaths is 22. Since 22 is lower than the 28 expected deaths, the 32 observed deaths are not statistically significantly different from the 28 expected deaths.

Limitations:

The major limitation of this methodology is the multiplication of 1990 or 1991 data by 20 to estimate the number of expected deaths for a 20-year period. Since cancer mortality rates have been increasing over the last twenty years, this technique will tend to over-estimate the expected number of cancer deaths. Additionally DOH did not actively ascertain the number of cancer deaths, but relied on a report from the community. If all the cancer deaths were not known to the people compiling the report, the observed number of cancer deaths may be underestimated.

The underestimation of observed deaths and overestimation of expected deaths may, in part, be balanced by incorrect designation of residency at time of death. Some cancer deaths attributed to Northport residents are likely to have been in those living outside the area. This assumption is based on the work done with inflammatory bowel and thyroid diseases, where some cases reported as Northport cases actually lived outside the boundaries encompassing the 600 residents of Northport and the surrounding area.

The potential overestimation of expected cancer deaths may also be tempered by assuming a population of 600. One community report estimated approximately 700 people in the Northport area. The estimated number of cancer deaths based on 700 people would be greater than the calculation based on 600 people.

Appendix B

Letter to Dr. Boyko

Ed Boyko, M.D.
V.A. Medical Center (111M)
1660 S. Columbian Way
Seattle, Washington 98108

Dear Dr. Boyko,

As I hope you recall, I spoke with you several months ago regarding what seems to be an excess of inflammatory bowel disease in the Northport, Washington area. I have enclosed three of our reports to the community. As you can see from the reports, the citizens have numerous health concerns and potential environmental exposures.

The Washington State Department of Health (DOH) has been reviewing material from the Northport area for over a year. We have concluded that the Northport area is unique in the variety of metals found in the soils, air and ground water. Given that most metals irritate the stomach lining, we wonder whether exposure to some of these metals is related to the incidence of IBD.

While our investigation focused on Northport and an area of 5 or 6 miles surrounding the town, we have reviewed several cases in Kettle Falls and received anecdotal evidence of cases in Colville. Additionally, our preliminary look at hospital discharge data indicates that hospitalization for regional enteritis (ICD9-CM 555), idiopathic proctocolitis (ICD9-CM 556)IBD, and other and unspecified noninfectious gastroenteritis and colitis (ICD9-CM 558.9) may be relatively high in the 4 counties in the Northwest corner of the state, especially, Okanogan, Ferry and Stevens Counties, when compared to Washington as a whole. Therefore, we suspect that rates of IBD may be elevated in a larger area than Northport.

The reports have a lot of information much of which may not be useful to you. However, I thought it best to present all of the information and let you decide what is useful. The sections on IBD are presented on pages 2 and 3 of the July 1992 report and pages 3 and 4 of the Summary report. Please note the first paragraph on page 3 of the Summary report is in error. I have noted this in the margin.

Page 7 of the November 1992 report contains a suggestion for screening cases with recent onset of IBD for copper. This proposal was somewhat of a rational stab in the dark, since management wanted a proposal for screening adults and did not like the idea of screening for a broad spectrum of metals. The screening was not done. One man who reported elevated blood copper seems to have been diagnosed with an inborn error of copper metabolism, although this is anecdotal.

I have a few suggestions as to where to go from here, but they are beyond the resources and/or current scope of activity of the Department of Health as sole investigator.

- Active case finding and documentation of IBD in a larger geographic area might be useful so that researchers would have a better understanding of where to look for clues about etiology. This would also be helpful if case-control or other studies were to be undertaken.

- One suggestion for a case-control study is screening for a broad spectrum of metals in newly diagnosed cases and matched controls. I would look beyond the Northport area to ascertain cases more rapidly.

- I have thought about storing hair and nail samples from a large cross-section of the population, waiting for disease to develop and pulling out a nested case-control study. This would be similar to what has been done with blood for studies of diet and cancer. It would obviously be a long term project.

- Since there seems to be geographic variation in the rates of morbidity and mortality of IBD in the U.S., maybe a first step would be an ecologic study to assess soil type and prevalence of IBD.

Please let me know if you want more specific information about the cases or any of the environmental findings. I am interested in any follow-up you may pursue and would be happy to assist in any way possible. While DOH is not in a position to be principal investigator, staff time can be devoted to follow-up projects related to this cluster of disease.

Sincerely,

Juliet VanEenwyk, Ph.D.

cc: Kim Field, Project Manager

Appendix C

Department of Ecology
Focus Sheet
Sulfur Dioxide

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Major Air Pollutants

Sulfur Dioxide

Background

Sulfur dioxide is a colorless liquid or gas with a very strong odor. It is one of the six air pollutants regulated by health-based standards of the federal government. Sulfur dioxide is produced by the combustion of fossil fuels at electrical power plants; industrial processes, such as copper smelting and pulp mills; and combustion in motor vehicle engines. Sulfur dioxide is most toxic when combined with small particles and moisture. The conversion of sulfur dioxide to sulfate particles is also considered a significant problem.

Sulfur dioxide in Washington State

Sulfur dioxide levels in Washington State have declined over the past ten years, probably due to the closure of the ASARCO smelter in Tacoma. However, the threat remains and violations of state standards are occasionally recorded near large industrial facilities. The coal-fired power plant near Centralia is a major contributor of sulfur dioxide in the state. Acid rain is a likely outcome should sulfur dioxide levels in Washington State increase.

Health effects

The major health concerns associated with high exposures to sulfur dioxide include effects on breathing and lung illnesses, changes in the lung's ability to defend itself, aggravation of existing respiratory and cardiovascular disease and death.

The people most sensitive to sulfur dioxide include asthmatics and individuals with chronic lung disease (such as bronchitis and emphysema) or cardiovascular disease, and people with allergies. Children and the elderly may also be sensitive. In persons with asthma, the clinical symptoms of brief exposure to low concentrations of sulfur dioxide are shortness of breath, wheezing and coughing.

People chronically exposed to sulfur dioxide have a higher incidence of persistent cough, shortness of breath, bronchitis, fatigue and colds of long duration. Research suggests that the federal standard is not protective of human health.

Other effects of sulfur dioxide

- Sulfur dioxide is one of the ingredients in the formation of acid rain. Acid rain acidifies lakes which destroys aquatic life and makes soil more acid. It can also damage building materials, cloth and metals.
- Sulfur dioxide can lead to decreased visibility because it causes a whitish haze.
- Sulfur dioxide can damage trees and agricultural crops. Some of these effects apparently occur at levels below the federal standard.

November 1992

F-A-92-27

printed on recycled paper

Controlling sulfur dioxide

The Clean Air Washington Act of 1991 tackles the air pollution problem in Washington State on many levels. The strategies of the Act to decrease the amount of sulfur dioxide in the air around us include:

- Permit program for industrial facilities, and
- Reduction of traffic and the use of single-occupancy vehicles.

More information

Ecology has prepared fact sheets on each element of Clean Air Washington, as well as major pollutants. These are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call:

Susan Campbell	Outreach Specialist	(206) 407-6825

Washington State Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

Appendix D

Cominco Slag in Lake Roosevelt

COMINCO SLAG IN LAKE ROOSEVELT

Review of Current Data

Prepared by:

Glen Patrick. Aquatic Toxicology Program Manager
Office of Toxic Substances
Environmental Health Programs
Washington State Department of Health

DECEMBER 1993

Washington State Department of Health

The Washington State Department of Health (DOH) was asked to evaluate the potential for human health impacts associated with exposure to fumed Cominco slag found on beaches of upper Lake Roosevelt. DOH reviewed recently published information regarding the characteristics and toxicity of fumed Cominco slag. Although the focus of this review is on potential human health implications, the topic of aquatic toxicity was also included.

The conclusions regarding human health expressed in this report are based on a preliminary assessment. For the purpose of this assessment, exposure assumptions used in this evaluation are believed to over-estimate an individuals likely exposure. Such assumptions ensure that conclusions regarding human health are protective yet add to the preliminary nature of the evaluation.

Background

The Cominco Ltd. lead/zinc smelter, located approximately ten miles from the international border in Trail B.C., has been in operation since the turn of the century and is today the world's largest lead/zinc smelter/refiner. The smelting process produces slag as a by-product, which undergoes a fuming process to further recover residual metals, primarily lead and zinc. This fuming process involves the injection of air and coal into molten slag which liberates metals as an oxide fume. The remaining molten slag is then mixed with water, producing a black, glassy, sand-like material referred to as fumed slag. Approximately 400 tons of fumed Cominco slag are produced per day and discharged to the Columbia River (Cominco, 1991).

In April 1991, in response to an inquiry by the Colville Confederated Tribes on the possible human health impacts of slag contaminated beaches on upper Lake Roosevelt, DOH reviewed existing data on slag discharged by Cominco Ltd. into the Columbia River. Sources of data for this review were the B.C. Ministry of Environment, Cominco Ltd., and the Department of Ecology; the primary source of slag data being Cominco Ltd. Based upon these data, this review concluded that slag discharged from Cominco Ltd. and found on the beaches of upper Lake Roosevelt, leaches negligible amounts of metals, including copper and zinc, is relatively inert and is of little human health concern.

Recent Studies

Recent studies of fumed Cominco slag have focused on the leachability of metals and aquatic organism toxicity (Nener, 1992; Godin and Hagen, 1992). The study by Nener (1992) presents data obtained by the Canadian Department of Fisheries and Oceans as part of its fisheries assessment on the toxicity of fumed slag to aquatic organisms. Four samples of fumed slag were collected from sewer No. 1; samples one and two were combined while samples three and four were analyzed separately. Standardized toxicity tests of Cominco slag were conducted on five test species representing various trophic levels: a unicellular green alga (*Selenastrum capricornutum*), zooplankton (*Daphnia magna*), an epibenthic invertebrate (*Hyalella azteca*), a benthic invertebrate (*Chironomus tentans*), and rainbow trout (*Oncorhynchus mykiss*) fingerlings. In addition, water samples from the various bioassays were analyzed for metals content. Finally, slag samples were digested using a combination of nitric and hydrochloric acids and analyzed by Inductively Coupled Plasma (ICP) to determine total metals content.

Godin and Hagen (1992) conducted a standard ten-day *Daphnia magna* bioassay on three samples of Columbia River sediment and one sample of fumed Cominco slag from sewer No. 1. Two of the sediment samples were collected from up-stream of Cominco Ltd. while the third sediment sample was collected from a down-stream location approximately midway between the international border and the Cominco Ltd. mill. Water used in these sediment bioassays was also analyzed.

As part of the Lake Roosevelt Water Quality Council activities, the U.S. Geological Survey (USGS) analyzed Lake Roosevelt bed sediments (not specifically slag material) collected from near the international boundary and conducted laboratory bioassays on this material.

Study Results

From Nener's (1992) study, fumed Cominco slag was found to be toxic to all species tested even when water hardness was adjusted upward. (Increasing water hardness generally results in a reduction of metals toxicity to aquatic organisms.) Toxicity was generally attributed to concentrations of dissolved and/or suspended zinc and copper for all species except rainbow trout. Trout gill tissue was found to be severely eroded after seven hours of exposure to slag. As stated in the report, "Concentrations of copper and zinc ... may also have resulted in mortality had fish survived the mechanical damage" (Nener, 1992).

The results from the Godin and Hagen (1992) *D. magna* bioassays on Cominco slag and downstream sediments were similar to the bioassay results from Nener (1992). Bioassays on slag obtained 100 percent mortality within 48 hours, while 100 percent mortality was obtained by day ten for the down-stream sediments. Results from bioassays conducted on Lake Roosevelt bed sediments by USGS also demonstrated a toxic response to aquatic organisms. The highest mortality rates (90 percent for *H. azteca* and 100 percent for *Ceriodaphnia dubia*) were observed for bed sediments collected from near the international boundary (Bortleson, G., written communication, 1993).

According to results from Nener (1992), total and dissolved metals concentrations in the bioassay supernate differed between the different bioassays. Concentrations of these metals appeared to be correlated with bioassay duration, although other factors may have contributed to this observation.

Total metals concentrations in the slag samples tested by Nener (1992) were similar to previously reported values. Slag was found to contain the following metals (listed by decreasing percentage): iron (31 percent), calcium (8.8 percent), aluminum (2.9 percent), zinc (2.4 percent) potassium (0.79 percent), manganese (0.60 percent), magnesium (0.57 percent) copper (0.35 percent), and barium (0.13 percent). A complete list of slag metal constituents is contained in Table 1. No organic chemical contamination was found to be associated with slag due to the processes involved and the lack of organic carbon necessary for binding such chemicals.

Human Health

With regard to the potential human health impacts resulting from Cominco fumed slag metals contamination, four exposure routes were considered: (1) inhalation of air-borne slag particles. (2) dermal contact with slag material. (3) ingestion of metals-contaminated lake water, and (4) direct ingestion of slag. Slag deposited along northern Lake Roosevelt shorelines during times of high water may become increasingly exposed as the Lake water level is lowered. While no tests have been conducted to assess the air-borne qualities of exposed and dried beach slag, Cominco Ltd., modelled the dispersion of dust and particulate matter from slag piles as part of their land slag disposal planning effort and concluded that dust and particulate matter will not be a concern due to wind erosion (Abby, B., personal communication, 1993). Empirical data from fumed slag sieve analysis indicate that approximately one percent (by weight) of discharged slag is less than 150 μm; 10 μm particles are generally considered respirable. Preliminary air monitoring data from the Northport vicinity did not indicate the presence of significant amounts of respirable particles regardless of source.

Citizens have reported that dermal contact with slag found on Lake Roosevelt beaches has resulted in skin irritation. While dermal contact with slag is not believed to be of human health concern from metals due to lack of significant absorption by skin, the physical characteristics of the slag, i.e., glass-like angular crystals, could result in skin abrasion especially of delicate skin on children.

Despite the leaching of metals from Cominco slag and the discharge of metals contaminated waste water from Cominco Ltd., the concentration of total metals, as measured in Lake Roosevelt water samples collected near Northport, did not exceed existing U.S. Environmental Protection Agency drinking water standards or ecological criteria.

Although analytical results show that slag contains numerous metals, the availability of these metals (i.e., the degree to which metals leach from the slag matrix) depends to a great extent on the pH of the receiving medium. Chemical analyses to determine the metals composition of Cominco slag require the use of a nitric and hydrochloric acid mixture to completely dissolve slag. Ingested slag would not be completely dissolved since human stomach gastric juices only have a pH of approximately 2. Slag digestion experiments conducted by B.C. Ministry of Environment (1979) indicate that at a pH of 2, lower concentrations of some metals were leached from fumed slag than was reported by Nener (1992) from full digestion. The degree to which metals would be leached from fumed slag (i.e., become biologically available) during human digestion due to other mechanical and chemical processes is not known.

To assess the significance of ingesting fumed Cominco slag, a tolerable ingestion amount was calculated for detected metals having a reference dose (RFD) Table 2. An RFD is by definition a daily human dose, with uncertainty spanning perhaps an order of magnitude, which is likely to be without an appreciable risk of deleterious effects during one's lifetime (EPA, 1989). A tolerable ingestion amount was calculated for young children (10 Kg, about 22 pounds) based on non-cancer endpoints (RFDs), mean slag chemical concentrations reported in Table 1, and 75 percent digestive absorption. Of the chemicals detected, eight did not have established RFDs and could not be evaluated. Six of these eight chemicals are known to be essential nutrients, while the remaining two (aluminum and lead) are not know to be of any human health benefit. From this evaluation, copper appears to be the slag metal with the smallest tolerable ingestion amount. Based on the above described exposure assumptions, a child weighing 10 kg could consume 4.0 grams of slag per month without risk of adverse health effects. If larger amounts of slag were consumed chronically, health effects from copper could result. Such effects include: vomiting, diarrhea, and stomach cramps. The consumption of a sufficient quantity of slag needed to produce an acute effect from metals toxicity is highly unlikely.

Conclusions

Findings from the above recent studies contradict previous conclusions, i.e. that Cominco slag leaches little and is biologically inert. These recent laboratory studies confirm that Cominco slag is toxic to all aquatic test species due to the leaching of significant amounts of copper and zinc and/or physical abrasion of vital tissues such as gills. Nener (1992) observed that increasing concentrations of dissolved metals in bioassay supernatant was associated with increases in bioassay duration (10 days vs 96 and 48 hours). This suggests that slag discharged to the Columbia River and Lake Roosevelt may continue to leach metals for a period of time. The findings from these studies suggest that discharge of Cominco slag into the Columbia River and ultimately Lake Roosevelt may have detrimental effects on the lake's aquatic ecosystem due to leaching of copper and zinc and from the physical characteristics of fumed slag.

Human exposure to fumed Cominco slag on beaches of Lake Roosevelt may result from inhalation, dermal contact, ingestion of lake water, and direct ingestion of slag material. The direct ingestion of slag is believed to be the exposure route of primary human health concern. Although children, and to a lesser extent adults, may inadvertently consume small amounts of slag from time to time, metal concentrations in slag are not sufficiently high to result in acute adverse health effects. It is also unlikely that a sufficient quantity of slag (greater than four grams per month, the volume of about four pennies) would be chronically consumed by a child so as to pose a significant long-term health concern. However, this assessment is based on many assumptions and does not account for an individual's total metal exposure from all routes, including drinking water and household dust. Additionally, the reduced leachability of beach slag, as a result of weathering, was also not addressed.

In summary, slag contains various metals as do non-slag contaminated sediments and soils. Recent studies indicate that slag is toxic to a variety of aquatic organisms and may be impacting the aquatic ecosystem in the Columbia River near the Canadian boarder. Available information is not sufficient to determine the amount of a metal which would be leached from slag found on Lake Roosevelt beaches, as it passes through the human digestive tract. If one assumes that the full concentration of each metal identified in fumed Cominco slag is available for gastro-intestinal absorption following human ingestion, then the metal of greatest concern is copper. Based on this scenario, a child could consume as much as four grams of slag per month or about the same volume as four pennies without experiencing adverse health impacts.

Table 1. Cominco Smelter, Trail, B.C., Slag Metals Content By Decreasing Percentage

Parameter (Total Metals)		Source Tap 1/2	Source Tap 3	Source Tap 4	Mean Conc. (mg/kg)	SD (N−1)	Percent
Iron	Fe	279000	339000	321000	313000	30789.6	31
Calcium	Ca	78300	96900	88500	87900.0	9314.5	8.8
Aluminum	Al	26700	31700	28800	29066.7	2510.6	2.9
Zinc	Zn	25500	26100	19900	23833.3	3419.6	2.4
Sodium	Na	9390	10500	8350	9413.3	1075.2	0.94
Potassium	K	8020	8400	7380	7933.3	515.5	0.79
Manganese	Mn	5330	6670	6020	6006.7	670.1	0.60
Magnesium	Mg	5330	6310	5440	5693.3	536.9	0.57
Copper	Cu	4100	3490	2780	3456.7	660.6	0.35
Barium	Ba	683	1190	2010	1294.3	669.6	0.13
Chromium	Cr	241	265	311	272.3	35.6	0.027
Cobalt	Co	248	333	190	257.0	71.9	0.026
Molybdenum	Mo	84.6	126	123	111.2	23.1	0.011
Arsenic	As	< 100	< 100	< 100	100.0	0.0	0.010
Vanadium	V	58.9	76.6	69	68.2	8.9	0.007
Phosphorus	P	< 50	< 50	< 50	50.0	0.0	0.005
Selenium	Se	< 50	< 50	< 50	50.0	0.0	0.005
Tin	Sn	< 30	< 30	< 30	30.0	0.0	0.003
Antimony	Sb	< 25	< 25	< 25	25.0	0.0	0.003
Nickel	Ni	30.6	22.3	17.2	23.4	6.8	0.002
Lead	Pb	16	32	14	20.7	9.9	0.002
Bismuth	Bi	< 10	< 10	< 10	10.0	0.0	0.001
Cadmium	Cd	10.7	9.1	8.2	9.3	1.3	0.001
Silver	Ag	9.5	14.4	< 2	8.6	6.2	0.001
Beryllium	Be	2.3	1.9	2.3	2.2	0.2	0.000
Mercury	Hg	< 0.005	< 0.005	< 0.005	0.0	0.0	0.000

< = Less than the detection limit shown

Concentrations are expressed as milligrams per kilogram (mg/kg) dry weight.

Data Source: Nener, Jennifer. July 1992. Survival and Water Quality Results of Bioassays on Five Species of Aquatic Organisms Exposed to Slag From Cominco's Trail Operations. Canadian Department of Fisheries and Oceans. Vancouver, B.C.

Table 2. Calculation of Tolerable Slag Ingestion Amounts For Detected Metals Based On Non-cancer Endpoints

Chemical	Units (Wet Wt.)	Mean Conc. (mg/kg)	RFD (mg/kg/day)		Exposure Assumptions Absorb. Coef.	Body Wt.(kg)	Ingest Amt. (g)	Ingest/ Month	Calculated Chem. Dose (mg/kg/day)
Aluminum	mg/kg	29067	N/A		0.75	10	0	1	--
Barium	mg/kg	1294	7.00E-02	1	0.75	10	21	1	6.70E-02
Beryllium	mg/kg	2.2	5.00E-03	2	0.75	10	900	1	4.88E-03
Cadmium	mg/kg	9.3	1.00E-03	1	0.75	10	42	1	9.63E-04
Calcium	mg/kg	87900	N/A		0.75	10	0	1	--
Chromium	mg/kg	272	5.00E-03	4	0.75	10	7	1	4.69E-03
Cobalt	mg/kg	257	N/A		0.75	10	0	1	--
Copper	mg/kg	3457	4.00E-02	3	0.75	10	4	1	3.41E-02
Iron	mg/kg	313000	N/A		0.75	10	0	1	--
Lead	mg/kg	20.7	N/A		0.75	10	0	1	--
Magnesium	mg/kg	5693	N/A		0.75	10	0	1	--
Manganese	mg/kg	6007	1.00E-01	1	0.75	10	6	1	8.89E-02
Molybdenum	mg/kg	111	5.00E-03	1	0.75	10	18	1	4.93E-03
Nickel	mg/kg	23.4	2.00E-02	1	0.75	10	340	1	1.96E-02
Potassium	mg/kg	7933	N/A		0.75	10	0	1	--
Silver	mg/kg	8.6	5.00E-03	1	0.75	10	225	1	4.77E-03
Sodium	mg/kg	9413	N/A		0.75	10	0	1	--
Vanadium	mg/kg	68.2	9.00E-03	1	0.75	10	50	1	8.41E-03
Zinc	mg/kg	23833	3.00E-01	1	0.75	10	5	1	2.94E-01

N/A - RFD Value Not Available

Concentrations given in mg/kg dry weight

1 - RFD from EPA IRIS database. (Oct. 92)

2 - Agency for Toxic Substances and Disease Registry (ATSDR)

3 - Value for Copper Calculated From Drinking Water Standard of 1.3 mg/l. (1.3mg/l x 2 l/d / 70kg = 0.037 = 4.0E-2

4 - RFD from EPA IRIS database (Oct. 92) for chromium (IV)

Abbey, B. 1993. Cominco LTD., Trail B.C. Personal Communication.

B.C. Ministry of Environment. 1979. Kootenay Air and Water Quality Study Phase II, Water Quality in the Lower Columbia River Basin. Victoria, B.C.

Bortleson, G. 1993. U.S. Geological Service, Tacoma, WA Office. Written Communication.

Cominco. 1991. Environmental Management Program: Slag Disposal Options - environmental and engineering studies.

EPA. 1989. Glossary of Terms Related to Health, Exposure, and Risk Assessment. Air Risk Information Support Center, Research Triangle Park, NC. EPA/450/3-88/016.

Godin, B., and Hagen, M. 1992. Cominco Sediment Bioassays, Sediment and Water Chemistry, October and November 1991. Environment Canada. North Vancouver, B.C.

Nener, J. 1992. Survival and Water Quality Results of Bioassays on Five Species of Aquatic Species of Aquatic Organism Exposed To Slag From Cominco's Trail Operations. Department of Fisheries and Oceans, Vancouver, B.C.

Appendix E

Leroi Smelter

U.S. ENVIRONMENTAL PROTECTION AGENCY SITE INSPECTION REPORT OF LEROI SMELTER COMPANY, NORTHPORT, WASHINGTON

On July 13, 1993, URS Consultants, Inc. (URS) conducted a site inspection (SI) of the LeRoi Company Smelter (LeRoi) site in Northport, Washington. The SI was conducted under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

The LeRoi site is located within the city limits of Northport. All the residents of Northport, approximately 358 people, live within a 1-mile radius of the site. No residents live on the LeRoi property. Six people are estimated to reside within 200 feet of the east boundary of the site (Site Inspection Report LeRoi Company Smelter, URS Consultants, Inc. November 3, 1993, page 3-6.).

The field sampling conducted at the LeRoi site was to gather data to evaluate potential soil problems associated with previous smelting operations conducted on-site. Sampling locations were selected to assess on-site conditions and possible release to the adjacent properties. The following samples were collected and analyzed for metals:

- On-site surface soils (near the probable former tailings area)
- Surface soils at adjacent city park
- Off-site (Background) surface soils (URS page 4-1)

Metals detected at significant concentrations on-site included arsenic, antimony, lead, and copper, which were potentially deposited on site as a result of the former smelter operations. Arsenic and copper were detected at a significant level off site in the adjacent city park soil sample. Cyanide was reported as undetected for all background and on-site samples (URS page 5-6, page 5-8).

The U.S. Environmental Protection Agency (EPA), does plans no further action at this site under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). This recommendation is based on the low probability of migration of potential site contaminants off-site.

Based on the SI and other pertinent information, EPA recommends the state further investigate and evaluate any possible exposure via the air or soil pathway (URS MEMORANDUM. October 29, 1993).

Appendix F

Derivation of Critical Organ Concentration for Cadmium

Derivation of Critical Organ Concentration of Cadmium

A mathematical model has been established estimating the accumulation of cadmium in the body. This model is based on various physiological and environmental variables which lead to an equation that estimates a body burden of cadmium in an individual. This equation is:

$$B_t = a \cdot \frac{1 - k^t}{1 - k}$$

where:

B_t = body burden at a certain time

a = cadmium absorbed daily for the period of time concerned

t = time of exposure to cadmium in days

k = fraction of body burden remaining after one day where:

$$k = 1 - e$$

and,

e = excretion constant, which is the fraction of the body burden excreted daily

By substituting the excretion constant (e) for the fraction of body burden remaining (k), the body burden equation becomes:

$$B_t = a \cdot \frac{1 - (1 - e)^t}{1 - (1 - e)}$$

Under the conditions existing in Northport and based on other data, the following values have been established for the required variables:

t = fifty years in days which is 18,250 days

e = 0.0001 based on a 19 year half life for cadmium in the human body which provides for a daily percent body burden excretion rate of 0.01%.

a = a variable daily intake amount depending on dietary intake, smoking rate, and ambient air intake, but once defined, remains constant over time "t". This value then becomes a_c since the intake is constant.

These values then provide for the following body burden equation:

$$B_{50yrs} = a_c \cdot \frac{1-(1-0.0001)^{18,250}}{1-(1-0.0001)} = a_c \cdot 8388 = 8388 \cdot a_c$$

Two values for a_c are derived to relate body burden based on dietary intake alone and based on dietary intake plus ambient air intake due to the established air-cadmium concentration.

For dietary intake alone, a_c is defined as the average daily dietary intake for the general population of 75 micrograms (μg) multiplied by 10% (amount of dietary intake absorbed into the body) by sensitive populations. This results in an a_c value of 7.5 μg.

The body burden value at fifty years then becomes:

$$B_{50yrs} = 8388(7.5\mu g) \approx 63{,}000\mu g$$

For dietary intake plus ambient air intake, a_c is defined as the average daily dietary absorbed intake for the general population (7.5 μg) plus the ambient air absorbed intake (R_{air}) which is defined as follows:

$$R_{air} = Cd_{air} \cdot V_d \cdot ar$$

where:

Cd_{air} = established cadmium concentration in the air (0.047 $\mu g/m^3$)

V_d = volume of air breathed/day (20 m^3/day)

ar = amount of cadmium inhaled that is absorbed into the body (25%)

The result is:

$$a_c = 7.5\mu g + R_{air} = 7.5\mu g + 0.235\mu g = 7.735\mu g$$

Based on both dietary and ambient air intakes, the body burden value at fifty years is then as follows:

$$B_{50yrs} = 8388(7.735\mu g) \approx 65{,}000\mu g$$

To determine the effect of this body burden on an individual after 50 yrs exposure, the concentration in the critical target organ, known to be the renal cortex, must first be determined. It has been previously established that a cadmium level in the kidney's renal cortex of 50 μg/g wet weight is considered deleterious for the general population, including sensitive members.

To determine what equivalent renal cortex levels the derived body burden levels are associated with, the cadmium level in the total kidney must first be obtained. Since it has been established that one third of all cadmium in the body is stored in the kidney, the body burden levels obtained must first be divided by three. Since the critical concentration is given in a per unit mass basis (1/g wet weight), the total kidney cadmium burden must be divided by the total kidney weight to determine the cadmium concentration in the kidney. This is done by dividing the kidney cadmium level by the total kidney weight (300 g). The following depicts these two calculations arithmetically:

$$[K] = \frac{B_{50yrs}(\mu g)}{3 \cdot 300(g)}$$

This value can then be used to determine what the critical organ concentration is since the renal cortex is known to store 60% of the total cadmium in the kidney. That is, the renal cortex contains 1.5 times as much cadmium, as can be found in the remainder of the kidney, the medulla. Thus, the renal cortex cadmium concentration ([RC]) can be written as follows:

$$[RC] = [K] \cdot 0.6$$

or by combining the last two equations, [RC] can be written as:

$$[RC] = 0.6 \cdot \frac{B_{50yrs}(\mu g)}{3 \cdot 300(g)} = \frac{B_{50yrs}}{1500} \frac{(\mu g)}{(g)}$$

For the body burdens derived previously, the renal cortex concentration for dietary intake alone is

42 μg/g wet weight,

and for dietary and ambient air intake, the renal cortex concentration is

43.3 μg/g wet weight

Both values are below the critical renal cortex concentration deemed to be deleterious which is 50 μg/g wet weight. There is very little margin of safety in these levels.

Reference: *Cadmium in the Environment, 2nd Edition.* Friberg L, Piscator M, Nordberg G, Kjellstrom T. 1974 CRC Press, Cleveland, OH.

Appendix G

Air Monitoring Data

LABORATORY ANALYSIS AND QUALITY ASSURANCE

Quality assurance was performed on only the seven metals identified. Filters selected for analysis were based on the specific sampler passing quality assurance audits, operator validation of the instruments operation, and laboratory validation of filter weight. Digestion of the TSP and PM-10 filters was performed using 100 milliliters of acid for the one by nine inch strip of filter. Digestion of the full 47 millimeter filter was performed in 25 milliliters of acid. The samples were analyzed by the following methods: Graphite furnace atomic absorption (GFAA) for arsenic and lead on specified filters, and Inductive coupled plasma (ICAP) for the remainder of the elements.

Instrument calibration was performed before each run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. Atomic absorption instrumentation calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements. Arsenic carryover was a problem in GFAA determinations, and the detection limit was raised from 1 to 3 ug/L to compensate for this carryover.

Procedural blanks associated with these samples showed no analytically significant levels of analytes, except on two samples with manganese levels below 16 ug/L which was flagged to reflect manganese contamination at 1.6 ug/L. Spike and duplicate spike sample analysis were performed on blank filters. All spike recoveries were within the CLP acceptance limits of +/- 25%. The results of the spike and duplicate spike samples were used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the +/-20% CLP acceptance window for duplicate analysis.

The following table provides instrument detection limits for the various metals.

Northport Air Sampling Lab Detection Limits

AIR VOL m^3	Parameter	LIMITS IN ug/m^3 FOR ELEMENTS SHOWN								
		AS	PB	As	Pb	Cd	Cu	Mn	Sb	Zn
58	SPM-10	0.00129	0.00043	0.01293	0.00862	0.00000	0.00129	0.00043	0.01293	0.00172
8	PPM-10	0.00938	0.00313	0.09375	0.06250	0.00003	0.00938	0.00313	0.09375	0.01250
1906	PM-10 /TSP	0.00142	0.00047	0.01417	0.00944	0.00000	0.00142	0.00047	0.01417	0.00189

**** GIVEN THE AVERAGE AIR FLOW AS SHOWN FOR THE PARAMETER INDICATED
THE METALS VALUES SHOWN ARE THE LOWER LIMITS OF DETECTION IN ug/m^3

Identification of sample analysis and calculation method

LAB LIMITS IN ug/l FOR ELEMENTS SHOWN								
AS	PB	As	Pb	Cd	Cu	Mn	Sb	Zn
3	1	30	20	0.01	3	1	30	4

********** For SPM-10 and PPM-10 filters were 100% of the sample was digested into an aqueous state of .025 liters :
ug/l represents the original analysis result renamed from "parts per million"
THEREFORE -> (ug/l)/40 recognizes the original aqueous sample as .025liters
and returns the actual ug in the sample

********** For PM-10 and TSP filters were 1/9 of the filter was digested into an aqueous state of .1 liters
ug/l represents the original analysis result renamed from "parts per million"
THEREFORE -> ug/l * .9 recognizes the original aqueous sample of .1 liters
and returns the approximate ug in the sample

********* ug/m^3 is the primary unit for air contaminations collected by deposition on a sample filter

PHASE I

AIR QUALITY MONITORING DATA

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 18-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		0.0000							
DATE: 19-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
14	Paparich/SPM-10		0.0000		0.0000							
DATE: 20-Dec-1992												
	Arnold/TSP											
	Kettle Falls/TSP											
17	Paparich/SPM-10		0.0000		.0830							
18	Paparich/TSP		.0602		.3545							
26	Jackman/TSP		.1126		.7292							
26	Worthen/TSP		.1118		.5883							
DATE: 21-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
14	Paparich/SPM-10		0.0000		0.0000							
DATE: 22-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		0.0000							
DATE: 23-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
0	Paparich/SPM-10		0.0000		0.0000							
DATE: 24-Dec-1992												
	Arnold/TSP											

SITE/PARAMETER	B	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V
DATE: 18-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 19-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 20-Dec-1992																						
Arnold/TSP																						
Kettle Falls/TSP																						
Paparich/SPM-10																						
Paparich/TSP																						
Jackman/TSP																						
Worthen/TSP																						
DATE: 21-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 22-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 23-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 24-Dec-1992																						
Arnold/TSP																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 24-Dec-1992												
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		0.0000							
DATE: 25-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		0.0000							
DATE: 26-Dec-1992												
	Arnold/TSP											
	Kettle Falls/TSP											
7	Paparich/SPM-10		0.0000		0.0000							
11	Worthen/TSP		0.0000		.0153							
12	Paparich/TSP											
13	Jackman/TSP											
DATE: 27-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		.5881							
DATE: 28-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
11	Paparich/SPM-10		0.0000		.9183							
DATE: 29-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/SPM-10											
	Paparich/TSP											
	Worthen/TSP											
DATE: 30-Dec-1992												
	Arnold/TSP											
	Jackman/TSP											

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 24-Dec-1992																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 25-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 26-Dec-1992																						
Arnold/TSP																						
Kettle Falls/TSP																						
Paparich/SPM-10																						
Worthen/TSP																						
Paparich/TSP																						
Jackman/TSP																						
DATE: 27-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 28-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 29-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/SPM-10																						
Paparich/TSP																						
Worthen/TSP																						
DATE: 30-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						

ug/m^3	******************** Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	**	Ag	Al
DATE: 30-Dec-1992													
	Kettle Falls/TSP												
	Paparich/TSP												
	Worthen/TSP												
0	Paparich/SPM-10												
DATE: 31-Dec-1992													
	Arnold/TSP												
	Jackman/TSP												
	Kettle Falls/TSP												
	Paparich/TSP												
	Worthen/TSP												
10	Paparich/SPM-10		0.0000		.1834								
DATE: 1-Jan-1993													
	Arnold/TSP												
9	Paparich/TSP		0.0000		.4873								
10	Paparich/SPM-10		0.0000		.2942								
13	Worthen/TSP		0.0000		.4235								
15	Kettle Falls/TSP		0.0000		.0430								
16	Jackman/TSP		0.0000		.2657								
DATE: 2-Jan-1993													
	Arnold/TSP												
	Jackman/TSP												
	Kettle Falls/TSP												
	Paparich/TSP												
	Worthen/TSP												
14	Paparich/SPM-10		0.0000		0.0000								
DATE: 3-Jan-1993													
	Arnold/TSP												
	Jackman/TSP												
	Kettle Falls/TSP												
	Paparich/TSP												
	Worthen/TSP												
17	Paparich/SPM-10		0.0000		.1280								
DATE: 4-Jan-1993													
	Arnold/TSP												
	Kettle Falls/TSP												
17	Paparich/TSP		.0262		.4689								
17	Worthen/TSP		.0363		.5338								
18	Jackman/TSP		.0308		.6039								
21	Paparich/SPM-10		0.0000		.0450								
DATE: 5-Jan-1993													
	Arnold/TSP												
	Jackman/TSP												
	Paparich/SPM-10												

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 30-Dec-1992																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 31-Dec-1992																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 1-Jan-1993																						
Arnold/TSP																						
Paparich/TSP																						
Paparich/SPM-10																						
Worthen/TSP																						
Kettle Falls/TSP																						
Jackman/TSP																						
DATE: 2-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 3-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 4-Jan-1993																						
Arnold/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Jackman/TSP																						
Paparich/SPM-10																						
DATE: 5-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Paparich/SPM-10																						

ug/m^3	******************** Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 5-Jan-1993												
	Paparich/TSP											
	Worthen/TSP											
9	Kettle Falls/TSP		0.0000		0.0000							
DATE: 6-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
17	Paparich/SPM-10		0.0000		.0588							
DATE: 7-Jan-1993												
	Arnold/TSP											
10	Paparich/SPM-10		0.0000		.3219							
19	Jackman/TSP		.0489		1.3835							
23	Paparich/TSP		.0606		1.6818							
24	Worthen/TSP		.0663		1.8878							
34	Kettle Falls/TSP		.0172		.4003							
DATE: 8-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
0	Paparich/SPM-10		0.0000		.0485							
DATE: 9-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
3	Paparich/SPM-10		0.0000		.0450							
DATE: 10-Jan-1993												
	Arnold/TSP											
	Paparich/TSP											
17	Kettle Falls/TSP		.0237		.3437							
17	Paparich/SPM-10		0.0000		.0519							
21	Jackman/TSP		.0976		.9371							
26	Worthen/TSP		.2106		1.1626							
DATE: 11-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 5-Jan-1993																						
Paparich/TSP																						
Worthen/TSP																						
Kettle Falls/TSP																						
DATE: 6-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 7-Jan-1993																						
Arnold/TSP																						
Paparich/SPM-10																						
Jackman/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Kettle Falls/TSP																						
DATE: 8-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 9-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 10-Jan-1993																						
Arnold/TSP																						
Paparich/TSP																						
Kettle Falls/TSP																						
Paparich/SPM-10																						
Jackman/TSP																						
Worthen/TSP																						
DATE: 11-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 11-Jan-1993												
	Worthen/TSP											
10	Paparich/SPM-10		.1073		0.0000							
DATE: 12-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
10	Paparich/SPM-10		0.0000		.0623							
DATE: 13-Jan-1993												
	Arnold/TSP											
0	Paparich/SPM-10											
13	Jackman/TSP		.0331		.7748							
14	Kettle Falls/TSP		0.0000		.4392							
19	Worthen/TSP		.0467		1.1624							
21	Paparich/TSP											
DATE: 14-Jan-1993												
	Arnold/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
16	Jackman/TSP		.0478		1.2251							
42	Paparich/SPM-10		.2493		.6025							
DATE: 15-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
35	Paparich/SPM-10		.1143		1.6551							
DATE: 16-Jan-1993												
	Arnold/TSP											
13	Jackman/TSP		.0439		.3617							
14	Paparich/SPM-10		0.0000		.3324							
22	Kettle Falls/TSP		0.0000		.2014							
22	Paparich/TSP		.0217		.2162							
23	Worthen/TSP		.1092		1.1765							
DATE: 17-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 11-Jan-1993																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 12-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 13-Jan-1993																						
Arnold/TSP																						
Paparich/SPM-10																						
Jackman/TSP																						
Kettle Falls/TSP																						
Worthen/TSP																						
Paparich/TSP																						
DATE: 14-Jan-1993																						
Arnold/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Jackman/TSP																						
Paparich/SPM-10																						
DATE: 15-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 16-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Paparich/SPM-10																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
DATE: 17-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 17-Jan-1993												
0	Paparich/SPM-10											
DATE: 18-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
0	Paparich/SPM-10											
DATE: 19-Jan-1993												
	Arnold/TSP											
	Paparich/TSP											
0	Paparich/SPM-10											
11	Jackman/TSP		.0171		.2293							
13	Kettle Falls/TSP		0.0000		.0443							
17	Worthen/TSP		.0177		.2106							
DATE: 20-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
10	Paparich/SPM-10		0.0000		0.0000							
DATE: 21-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
0	Paparich/SPM-10		0.0000		0.0000							
DATE: 22-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Worthen/TSP											
3	Paparich/SPM-10		0.0000		.2676							
6	Paparich/TSP		0.0000		.0186							
DATE: 23-Jan-1993												
	Arnold/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
5	Jackman/TSP		0.0000		.1464							
10	Paparich/SPM-10		0.0000		0.0000							

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 17-Jan-1993																						
Paparich/SPM-10																						
DATE: 18-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 19-Jan-1993																						
Arnold/TSP																						
Paparich/TSP																						
Paparich/SPM-10																						
Jackman/TSP																						
Kettle Falls/TSP																						
Worthen/TSP																						
DATE: 20-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 21-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 22-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Paparich/TSP																						
DATE: 23-Jan-1993																						
Arnold/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Jackman/TSP																						
Paparich/SPM-10																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 24-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
24	Paparich/SPM-10		0.0000		.0727							
DATE: 25-Jan-1993												
	Arnold/TSP											
0	Paparich/SPM-10		0.0000		.3289							
17	Kettle Falls/TSP		0.0000		.0689							
18	Jackman/TSP		.1076		1.9076							
26	Paparich/TSP		.0917		2.1647							
34	Worthen/TSP		.1071		2.2895							
DATE: 26-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
14	Paparich/SPM-10		0.0000		0.0000							
DATE: 27-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
0	Paparich/SPM-10		0.0000		0.0000							
DATE: 28-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		.2780							
18	Paparich/TSP		.0797		.1659							
DATE: 29-Jan-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
10	Paparich/SPM-10		0.0000		.2181							
DATE: 30-Jan-1993												
	Arnold/TSP											

SITE/PARAMETER	B	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V
DATE: 24-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 25-Jan-1993																						
Arnold/TSP																						
Paparich/SPM-10																						
Kettle Falls/TSP																						
Jackman/TSP																						
Paparich/TSP																						
Worthen/TSP																						
DATE: 26-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 27-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 28-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Paparich/TSP																						
DATE: 29-Jan-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 30-Jan-1993																						
Arnold/TSP																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 30-Jan-1993												
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
0	Paparich/SPM-10		0.0000		0.0000							
9	Jackman/TSP		0.0000		.0879							
DATE: 31-Jan-1993												
	Arnold/TSP											
7	Paparich/SPM-10		0.0000		.1731							
12	Paparich/TSP		.0405		.2948							
15	Jackman/TSP		.0781		.6003							
18	Kettle Falls/TSP		0.0000		.0110							
34	Worthen/TSP		.0611		.5144							
DATE: 1-Feb-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		0.0000							
DATE: 2-Feb-1993												
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
3	Paparich/SPM-10		0.0000		0.0000							
12	Arnold/TSP		0.0000		.0415							
DATE: 3-Feb-1993												
	Arnold/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
3	Paparich/SPM-10		0.0000		.2800							
14	Jackman/TSP		.0321		.3448							
18	Worthen/TSP		.0509		.5444							
DATE: 4-Feb-1993												
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		.3116							
16	Arnold/TSP		.0257		.3397							
DATE: 5-Feb-1993												
	Arnold/TSP											
	Jackman/TSP											

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 30-Jan-1993																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Jackman/TSP																						
DATE: 31-Jan-1993																						
Arnold/TSP																						
Paparich/SPM-10																						
Paparich/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Worthen/TSP																						
DATE: 1-Feb-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 2-Feb-1993																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Arnold/TSP																						
DATE: 3-Feb-1993																						
Arnold/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Paparich/SPM-10																						
Jackman/TSP																						
Worthen/TSP																						
DATE: 4-Feb-1993																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Arnold/TSP																						
DATE: 5-Feb-1993																						
Arnold/TSP																						
Jackman/TSP																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 5-Feb-1993												
	Kettle Falls/TSP											
	Worthen/TSP											
14	Paparich/SPM-10		0.0000		.2710							
27	Paparich/TSP		.0434		.4803							
DATE: 6-Feb-1993												
	Paparich/TSP											
0	Paparich/SPM-10											
36	Arnold/TSP		.0937		1.0208							
40	Kettle Falls/TSP											
45	Jackman/TSP		.1186		1.5667							
56	Worthen/TSP		.1424		1.8102							
DATE: 7-Feb-1993												
	Arnold/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
0	Paparich/SPM-10											
54	Jackman/TSP		.0544		1.2567							
DATE: 8-Feb-1993												
	Jackman/TSP											
	Kettle Falls/TSP											
0	Paparich/SPM-10											
16	Arnold/TSP		.0282		.2042							
21	Worthen/TSP		.0439		.5312							
24	Paparich/TSP		.0366		.7525							
DATE: 9-Feb-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
14	Paparich/SPM-10		0.0000		0.0000							
51	Worthen/TSP		.1727		1.5536							
DATE: 10-Feb-1993												
	Kettle Falls/TSP											
	Worthen/TSP											
14	Paparich/SPM-10		0.0000		.7814							
20	Arnold/TSP		.0168		.1831							
29	Jackman/TSP		0.0000		.1329							
31	Paparich/TSP		.0740		.6411							
DATE: 11-Feb-1993												
	Arnold/TSP											
	Jackman/TSP											
	Kettle Falls/TSP											

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 5-Feb-1993																						
Kettle Falls/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Paparich/TSP																						
DATE: 6-Feb-1993																						
Paparich/TSP																						
Paparich/SPM-10																						
Arnold/TSP																						
Kettle Falls/TSP																						
Jackman/TSP																						
Worthen/TSP																						
DATE: 7-Feb-1993																						
Arnold/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Jackman/TSP																						
DATE: 8-Feb-1993																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/SPM-10																						
Arnold/TSP																						
Worthen/TSP																						
Paparich/TSP																						
DATE: 9-Feb-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Paparich/SPM-10																						
Worthen/TSP																						
DATE: 10-Feb-1993																						
Kettle Falls/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Arnold/TSP																						
Jackman/TSP																						
Paparich/TSP																						
DATE: 11-Feb-1993																						
Arnold/TSP																						
Jackman/TSP																						
Kettle Falls/TSP																						

ug/m^3	******************** Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 11-Feb-1993												
	Paparich/TSP											
21	Paparich/SPM-10		0.0000		.1821							
37	Worthen/TSP		.1113		1.1231							
DATE: 12-Feb-1993												
	Paparich/TSP											
	Worthen/TSP											
27	Arnold/TSP		.0325		.3782							
27	Kettle Falls/TSP											
31	Jackman/TSP		.0648		.7575							
31	Paparich/SPM-10		0.0000		.7590							
DATE: 13-Feb-1993												
	Arnold/TSP											
	Kettle Falls/TSP											
11	Jackman/TSP		0.0000		.0456							
15	Paparich/TSP		0.0000		.1433							
18	Worthen/TSP		0.0000		.1123							
24	Paparich/SPM-10		0.0000		.3460							
DATE: 14-Feb-1993												
	Jackman/TSP											
	Kettle Falls/TSP											
	Paparich/TSP											
	Worthen/TSP											
7	Paparich/SPM-10		0.0000		.1380							
20	Arnold/TSP		0.0000		.0192							

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 11-Feb-1993																						
Paparich/TSP																						
Paparich/SPM-10																						
Worthen/TSP																						
DATE: 12-Feb-1993																						
Paparich/TSP																						
Worthen/TSP																						
Arnold/TSP																						
Kettle Falls/TSP																						
Jackman/TSP																						
Paparich/SPM-10																						
DATE: 13-Feb-1993																						
Arnold/TSP																						
Kettle Falls/TSP																						
Jackman/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
DATE: 14-Feb-1993																						
Jackman/TSP																						
Kettle Falls/TSP																						
Paparich/TSP																						
Worthen/TSP																						
Paparich/SPM-10																						
Arnold/TSP																						

PHASE II

AIR QUALITY MONITORING

DATA

ug/m^3	******************** Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 9-Jul-1993												
18	Paparich/TSP		.0237	.1833	.1819	.0096	.0482	.0030	.0650	.3806	.0014	.0508
DATE: 14-Jul-1993												
18	Paparich/TSP		.0133	.2302	.2249	.0108	.0802	.0037	.0207	.3738	.0004	.0879
DATE: 18-Jul-1993												
16	Paparich/TSP		0.0000	.0047	.0031	.0007	.0835	.0020	0.0000	.0173	.0004	.0471
DATE: 24-Jul-1993												
26	Paparich/TSP		0.0000	.0070	.0031	.0010	.1031	.0059	.0014	.0340	.0003	.1294
DATE: 30-Jul-1993												
34	Paparich/TSP			.0727								
DATE: 5-Aug-1993												
39	Paparich/TSP		0.0000	.1195	.1066	.0037	.0892	.0173	.0099	.2045	.0011	.3384
DATE: 10-Aug-1993												
	Paparich/SPM-10											
DATE: 11-Aug-1993												
	Paparich/SPM-10											
DATE: 12-Aug-1993												
27	Paparich/SPM-10											
DATE: 13-Aug-1993												
14	China Bend/PM-10	.0062	0.0000		.0644	.0040	.0225	.0045	.0243	.1146	.0004	.0853
18	Paparich/SPM-10	.0124	.0141		.1478	.0090	.0066	.0074	.0336	.2103	.0005	.1491
22	Paparich/PM-10	.0124	.0073		.1590	.0093	.0156	.0091	.0348	.2281	.0009	.1579
26	Paparich/TSP		0.0000	.1648	.1576	.0078	.0501	.0121	.0365	.2652	.0008	.2348
31	Kettle Falls/PM-10	.0017	0.0000		.0144	.0009	.0224	.0186	0.0000	.0336	.0002	.2505
DATE: 14-Aug-1993												
18	Paparich/SPM-10	.0187	.0159		.2660	.0118	.0015	.0075	.0459	.2288	.0010	.1422
DATE: 15-Aug-1993												
16	Paparich/SPM-10	.0350	.0277		.3551	.0164	.0018	.0020	.0799	.1982	.0004	.0221
DATE: 16-Aug-1993												
18	Paparich/SPM-10	.0239	.0300		.2172	.0096	.0022	.0024	.0636	.1847	.0003	.0352
DATE: 17-Aug-1993												

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 9-Jul-1993																						
Paparich/TSP	.0080	.0017	0.0000	.2693	.2537	.0008	.0012	.0575	.1037	.4249	.0555	.0752	.0008	.6597	.0026	.0018	.2504	.0064	.0007	.0019	.0098	0.000
DATE: 14-Jul-1993																						
Paparich/TSP	.0060	.0031	0.0000	.5329	.5117	.0004	.0021	.0800	.1260	.3950	.0685	.0933	.0013	.5793	.0023	.0071	.1848	.0026	.0008	.0025	.0019	0.000
DATE: 18-Jul-1993																						
Paparich/TSP	.0049	.0011	0.0000	.2628	.2469	.0008	.0005	.0404	.1030	.4252	.0498	.0713	.0004	.4593	.0039	.0027	.1273	.0023	.0005	.0015	.0133	0.000
DATE: 24-Jul-1993																						
Paparich/TSP	.0099	.0032	0.0000	.5736	.5466	0.0000	.0010	.0857	.1481	.6955	.0952	.1186	.0008	.6837	.0009	.0101	.2290	.0030	.0037	.0028	.0116	0.000
DATE: 30-Jul-1993																						
Paparich/TSP																						
DATE: 5-Aug-1993																						
Paparich/TSP	.0162	.0071	0.0000	3.2373	3.1112	0.0000	.0013	.4054	.4856	.4528	.2333	.2521	.0005	.6614	.0015	.0042	.5784	.0000	.0038	.0210	.0130	.001
DATE: 10-Aug-1993																						
Paparich/SPM-10																						
DATE: 11-Aug-1993																						
Paparich/SPM-10																						
DATE: 12-Aug-1993																						
Paparich/SPM-10																						
DATE: 13-Aug-1993																						
China Bend/PM-10	.0098	.0104	0.0000	.4548	.4374	.0008	.0004	.1083	.1445	.3369	.0832	.0976	.0001	.6085	0.0000	0.0000	.2225	0.0000	.0010	.0048	.0021	0.000
Paparich/SPM-10	.0130	.0147	.0000	1.1306	1.1294	.0003	.0006	.1695	.0851	0.0000	.1078	.0702	0.0000	.7987	0.0000	0.0000	.5832	0.0000	.0013	.0085	0.0000	.000
Paparich/PM-10	.0150	.0112	0.0000	1.1886	1.1465	.0008	.0012	.1861	.2483	.3702	.1286	.1465	.0012	.6359	0.0000	.0069	.3163	.0060	.0019	.0096	.0072	0.000
Paparich/TSP	.0107	.0121	0.0000	1.4418	1.3873	.0010	.0009	.2368	.2928	.4258	.1497	.1683	.0008	.5687	.0019	.0026	.3478	.0066	.0025	.0127	.0026	.001
Kettle Falls/PM-10	.0122	.0085	0.0000	.6912	.6693	.0012	.0013	.3270	.3691	.5414	.1942	.2030	.0009	.4370	0.0000	0.0000	.5393	.0023	.0029	.0123	.0069	.000
DATE: 14-Aug-1993																						
Paparich/SPM-10	.0166	.0051	.0001	.8192	.8253	0.0000	.0010	.1658	.0764	0.0000	.0905	.0463	0.0000	1.0455	.0004	.0019	.6915	0.0000	.0010	.0096	0.0000	.001
DATE: 15-Aug-1993																						
Paparich/SPM-10	.0187	.0013	.0001	.2987	.3065	.0009	.0009	.0328	0.0000	0.0000	.0391	0.0000	0.0000	.9002	0.0000	.0179	.4889	0.0000	.0001	.0012	.0108	.000
DATE: 16-Aug-1993																						
Paparich/SPM-10	.0142	.0019	.0001	.3567	.3655	0.0000	.0007	.0551	0.0000	0.0000	.0554	.0119	0.0000	.9455	0.0000	.0020	1.0392	.0018	.0002	.0019	0.0000	.000
DATE: 17-Aug-1993																						

ug/m^3	******************** Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 17-Aug-1993												
6	B.C. Northport/PM-10	.0100		.0200		.0100				.0700		
6	B.C. Northport/PM-10	.0100		.0200		.0100				.0700		
11	Paparich/PM-10	.0018	0.0000		.0004	.0001	.0205	.0018	0.0000	.0087	.0002	.0286
12	China Bend/PM-10	.0017	0.0000		0.0000	.0001	.0335	.0018	0.0000	.0103	.0003	.0298
12	Paparich/TSP		0.0000	.0026	0.0000	0.0000	.0379	.0017	.0023	.0144	.0002	.0386
13	Kettle Falls/PM-10	.0017	0.0000		0.0000	.0001	.0348	.0038	.0007	.0154	0.0000	.0389
DATE: 19-Aug-1993												
	Paparich/SPM-10											
DATE: 20-Aug-1993												
22	Paparich/SPM-10	.0265	.0251		.1651	.0057	.0013	.0040	.0412	.2609	.0010	.0450
DATE: 21-Aug-1993												
	Paparich/SPM-10											
DATE: 23-Aug-1993												
14	B.C. Northport/PM-10	.0200		.0600		.0100				.1200		
14	B.C. Northport/PM-10	.0200		.0600		.0100				.1200		
14	China Bend/PM-10	.0154	.0169		.0944	.0074	.0273	.0020	.0172	.0704	0.0000	.0374
19	Paparich/PM-10	.0163	.0135		.0879	.0101	.0144	.0086	.0267	.1135	.0005	.1265
31	Paparich/TSP		.0040	.0894	.0797	.0091	.0196	.0126	.0257	.1539	.0005	.2674
33	Kettle Falls/PM-10	.0017	0.0000		.0048	.0003	.0478	.0225	0.0000	.0158	.0004	.3231
34	B.C. Northport/TSP	.0100		.0600		.0100				.1500		
34	B.C. Northport/TSP	.0100		.0600		.0100				.1500		
DATE: 25-Aug-1993												
8	Paparich/SPM-10	.0043	.0044		.0226	.0017	.0018	.0013	.0071	.0259	.0001	.0148
DATE: 26-Aug-1993												
13	Paparich/SPM-10	.0124	.0141		.1534	.0057	.0008	.0027	.0213	.0843	.0003	.0478
DATE: 27-Aug-1993												
11	Paparich/SPM-10	.0018	0.0000		.0186	.0011	.0013	.0049	.0052	.0406	.0000	.2067
DATE: 28-Aug-1993												
9	Paparich/SPM-10	.0094	.0123		.0997	.0083	.0026	.0024	.0123	.1009	.0006	.0381
DATE: 29-Aug-1993												
12	Paparich/SPM-10	.0149	.0098		.0952	.0080	.0082	.0033	.0222	.1166	.0002	.0557
14	B.C. Northport/PM-10	.0100		.1200		.0100				.1400		

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 17-Aug-1993																						
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Paparich/PM-10	.0113	.0054	0.0000	.1627	.1531	0.0000	.0007	.0307	.0707	.3512	.0438	.0612	.0002	.6012	.0010	.0002	.1712	.0042	.0005	.0012	.0105	0.000
China Bend/PM-10	.0079	.0067	0.0000	.1988	.1872	.0012	.0011	.0362	.0648	.3908	.0487	.0677	.0010	.6073	.0018	.0017	.1599	.0051	.0005	.0011	.0005	0.000
Paparich/TSP	.0056	.0049	0.0000	.1751	.1637	.0007	.0012	.0328	.0715	.3884	.0427	.0631	.0007	.4247	.0006	0.0000	.0995	.0015	.0005	.0010	.0115	0.000
Kettle Falls/PM-10	.0073	.0083	0.0000	.3015	.2891	0.0000	.0009	.0570	.0872	.2996	.0777	.0898	.0005	.5496	0.0000	.0012	.1366	0.0000	.0011	.0021	.0038	0.000
DATE: 19-Aug-1993																						
Paparich/SPM-10																						
DATE: 20-Aug-1993																						
Paparich/SPM-10	.0120	.0027	.0001	.6435	.6535	0.0000	0.0000	.0733	0.0000	0.0000	.0628	.0156	0.0000	.8636	0.0000	0.0000	.4369	.0007	.0005	.0029	0.0000	0.000
DATE: 21-Aug-1993																						
Paparich/SPM-10																						
DATE: 23-Aug-1993																						
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
China Bend/PM-10	.0093	.0018	0.0000	.2846	.2706	.0008	.0007	.0366	.0813	.3565	.0455	.0611	.0004	.6913	0.0000	0.0000	.2044	.0084	.0004	.0017	.0081	0.000
Paparich/PM-10	.0090	.0034	0.0000	.4506	.4330	0.0000	.0004	.1718	.2072	.4304	.0883	.1042	.0006	.6424	.0021	.0110	.3801	.0031	.0012	.0105	.0048	.000
Paparich/TSP	.0107	.0051	0.0000	.6410	.6161	.0014	.0009	.2882	.3320	.4661	.1277	.1446	.0006	.6231	.0017	0.0000	.7625	.0037	.0020	.0187	.0214	0.000
Kettle Falls/PM-10	.0116	.0112	0.0000	.8450	.8153	.0012	.0018	.4224	.4609	.5230	.2056	.2229	0.0000	.7993	.0002	0.0000	.6195	.0071	.0035	.0222	.0150	.000
B.C. Northport/TSP																						
B.C. Northport/TSP																						
DATE: 25-Aug-1993																						
Paparich/SPM-10	.0096	.0014	.0001	.3498	.3613	0.0000	.0010	.0266	0.0000	0.0000	.0398	0.0000	0.0000	.8532	0.0000	.0033	.4497	0.0000	.0001	.0013	0.0000	.000
DATE: 26-Aug-1993																						
Paparich/SPM-10	.0050	.0021	0.0000	.6889	.6870	.0009	.0006	.0618	0.0000	0.0000	.0610	.0217	0.0000	.7345	0.0000	.0012	.4906	0.0000	.0004	.0029	0.0000	.000
DATE: 27-Aug-1993																						
Paparich/SPM-10	.0403	.0032	.0000	.8252	.8170	0.0000	.0006	.1078	.0294	0.0000	.0780	.0448	0.0000	.9905	0.0000	.0026	.9149	0.0000	.0007	.0060	0.0000	.000
DATE: 28-Aug-1993																						
Paparich/SPM-10	.0081	.0018	.0000	.8056	.8013	0.0000	.0007	.0470	0.0000	0.0000	.0556	.0182	0.0000	.8056	0.0000	.0013	.4684	0.0000	.0004	.0023	.0027	0.000
DATE: 29-Aug-1993																						
Paparich/SPM-10	.0232	.0158	0.0000	1.0005	.9810	0.0000	.0009	.0706	.0095	0.0000	.0668	.0395	0.0000	.8141	0.0000	.0064	.5250	.0011	.0009	.0034	0.0000	.001
B.C. Northport/PM-10																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 29-Aug-1993												
14	B.C. Northport/PM-10	.0100		.1200		.0100				.1400		
14	Kettle Falls/PM-10	.0095	.0102		.0483	.0042	.0447	.0054	.0065	.0439	.0020	.0565
14	Paparich/PM-10	.0175	.0058		.1182	.0107	.0276	.0031	.0207	.1199	.0007	.0562
18	Paparich/TSP		.0035	.1510	.1513	.0106	.0390	.0054	.0130	.2085	.0006	.0943
23	China Bend/PM-10	.0096	.0029		.0335	.0046	.0216	.0062	.0185	.0534	.0001	.1204
30	B.C. Northport/TSP	.0100		.0900		.0100				.0800		
30	B.C. Northport/TSP	.0100		.0900		.0100				.0800		
DATE: 30-Aug-1993												
19	Paparich/SPM-10	.0154	.0125		.1605	.0084	.0017	.0069	.0237	.3141	0.0000	.1137
DATE: 31-Aug-1993												
19	Paparich/SPM-10	.0093	.0062		.0714	.0074	.0029	.0087	.0142	.0847	.0001	.1859
DATE: 1-Sep-1993												
22	Paparich/SPM-10	.0251	.0249		.1734	.0082	.0011	.0064	.0487	.1464	.0003	.1620
DATE: 2-Sep-1993												
43	Paparich/SPM-10	.0199	.0188		.1644	.0064	.0010	.0170	.0303	.1764	0.0000	.3139
DATE: 3-Sep-1993												
38	Paparich/SPM-10	.0024	0.0000		.0140	.0019	.0020	.0140	.0023	.0223	0.0000	.3726
DATE: 4-Sep-1993												
17	China Bend/PM-10	.0113	0.0000		.0700	.0024	.0232	.0055	.0138	.0902	.0001	.1062
29	B.C. Northport/PM-10	.0500		.1400		.0100				.2100		
29	B.C. Northport/PM-10	.0500		.1400		.0100				.2100		
31	Kettle Falls/PM-10	.0117	0.0000		.0735	.0024	.0351	.0156	.0135	.0914	.0002	.2012
46	B.C. Northport/TSP	.0400		.1700		.0100				.3900		
46	B.C. Northport/TSP	.0400		.1700		.0100				.3900		
51	Paparich/SPM-10	.0166	.0148		.1139	.0033	.0117	.0257	.0487	.1813	.0002	.5661
62	Paparich/TSP		.0092	.1516	.1409	.0043	.0477	.0243	.0387	.3154	.0011	.4511
64	Paparich/PM-10	.0191	.0125		.1397	.0049	.0327	.0308	.0428	.1931	.0006	.4441
DATE: 5-Sep-1993												
56	Paparich/SPM-10	.0445	.0444		.3563	.0111	.0039	.0269	.0544	.2900	.0000	.5847
DATE: 6-Sep-1993												
39	Paparich/SPM-10	.0201	.0168		.1825	.0083	.0020	.0209	.0265	.2035	.0010	.4857
DATE: 7-Sep-1993												
44	Paparich/SPM-10	.0191	.0217		.2282	.0113	.0015	.0151	.0203	.1579	.0010	.3682

***************** SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 29-Aug-1993																						
B.C. Northport/PM-10																						
Kettle Falls/PM-10	.0110	.0024	0.0000	.3453	.3306	.0008	.0010	.0730	.1041	.3537	.0803	.0975	.0008	.6555	0.0000	0.0000	.2365	.0024	.0010	.0027	.0171	0.000
Paparich/PM-10	.0097	.0038	0.0000	1.0897	1.0514	0.0000	.0012	.0714	.1292	.3429	.0735	.0946	.0005	.6754	0.0000	0.0000	.2162	.0051	.0011	.0032	.0082	.000
Paparich/TSP	.0064	.0062	0.0000	1.4900	1.4456	.0004	.0094	.1183	.1548	.2772	.0949	.1104	.0006	.5808	.0023	.0035	.2214	.0052	.0014	.0048	.0065	0.000
China Bend/PM-10	.0105	.0086	0.0000	.2522	.2379	.0012	.0017	.1517	.1957	.4239	.0751	.0966	.0010	.7819	0.0000	0.0000	.3630	.0051	.0010	.0092	.0153	.000
B.C. Northport/TSP																						
B.C. Northport/TSP																						
DATE: 30-Aug-1993																						
Paparich/SPM-10	.0070	.0052	0.0000	1.7483	1.7140	0.0000	.0010	.1457	.0951	0.0000	.1015	.0702	0.0000	.7542	0.0000	.0069	.7354	0.0000	.0012	.0072	0.0000	.000
DATE: 31-Aug-1993																						
Paparich/SPM-10	.0108	.0070	0.0000	2.0296	1.9939	0.0000	.0006	.2090	.1307	0.0000	.1421	.1059	0.0000	.9949	0.0000	.0019	1.6225	0.0000	.0016	.0102	0.0000	.000
DATE: 1-Sep-1993																						
Paparich/SPM-10	.0196	.0046	0.0000	2.3604	2.3229	0.0000	.0002	.1964	.1367	0.0000	.1390	.1048	0.0000	1.0458	.0008	.0137	1.0813	0.0000	.0016	.0086	.0021	0.000
DATE: 2-Sep-1993																						
Paparich/SPM-10	.0073	.0092	.0000	6.8927	6.6858	0.0000	.0009	.4031	.3968	0.0000	.3047	.2818	0.0000	.8345	0.0000	.0013	.8346	0.0000	.0041	.0198	0.0000	.001
DATE: 3-Sep-1993																						
Paparich/SPM-10	.0205	.0098	0.0000	5.5965	5.4488	0.0000	.0015	.4319	.4124	0.0000	.3065	.2824	0.0000	.9979	0.0000	.0037	1.1455	.0018	.0039	.0237	0.0000	.001
DATE: 4-Sep-1993																						
China Bend/PM-10	.0111	.0068	0.0000	.6830	.6599	.0004	.0007	.1457	.1772	.3200	.1064	.1206	.0010	.6240	0.0000	0.0000	.3292	.0036	.0011	.0065	.0126	0.000
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Kettle Falls/PM-10	.0121	.0087	0.0000	.7452	.7226	.0008	.0012	.2990	.3257	.3867	.2311	.2372	.0006	.6650	.0011	0.0000	.4271	.0007	.0023	.0119	.0079	.000
B.C. Northport/TSP																						
B.C. Northport/TSP																						
Paparich/SPM-10	.0137	.0190	0.0000	7.6820	7.4712	0.0000	.0015	.6479	.6456	0.0000	.4025	.3785	0.0000	.9937	.0001	.0079	1.7032	.0027	.0055	.0352	0.0000	.001
Paparich/TSP	.0087	.0120	0.0000	9.4871	9.0399	.0003	.0013	.6297	.7693	.4557	.4632	.4862	.0006	.6688	.0011	.0012	.7568	.0067	.0061	.0305	.0163	.001
Paparich/PM-10	.0107	.0139	0.0000	8.5441	8.1631	.0003	.0017	.5950	.7201	.4288	.4049	.4312	.0010	.6772	.0035	0.0000	.6907	.0056	.0060	.0296	.0101	.000
DATE: 5-Sep-1993																						
Paparich/SPM-10	.0117	.0146	.0000	7.8559	7.5943	0.0000	.0005	.6733	.6809	0.0000	.3959	.3787	0.0000	1.0065	.0044	.0131	1.5157	.0028	.0054	.0366	0.0000	.001
DATE: 6-Sep-1993																						
Paparich/SPM-10	.0274	.0150	.0000	6.0968	5.9165	0.0000	.0007	.5458	.5372	0.0000	.3193	.3018	0.0000	.9346	0.0000	.0018	1.4571	.0007	.0043	.0303	0.0000	.002
DATE: 7-Sep-1993																						
Paparich/SPM-10	.0159	.0111	0.0000	6.2315	6.0237	0.0000	.0012	.4498	.4537	0.0000	.3148	.3007	0.0000	.9517	.0004	.0051	1.0079	0.0000	.0040	.0226	0.0000	.001

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 8-Sep-1993												
24	Paparich/SPM-10	.0245	.0183		.1413	.0072	.0017	.0142	.0223	.1339	.0004	.3056
DATE: 9-Sep-1993												
26	Paparich/SPM-10	.0625	.0590		.1942	.0070	.0017	.0129	.1193	.2048	.0000	.2495
DATE: 10-Sep-1993												
22	China Bend/PM-10	.0078	.0051		.0566	.0030	.0351	.0096	.0117	.0648	0.0000	.1457
39	Paparich/SPM-10	.0145	.0144		.1124	.0046	.0095	.0162	.0227	.1412	0.0000	.3646
42	Kettle Falls/PM-10	.0082	.0015		.0606	.0025	.0274	.0278	.0121	.0647	.0004	.3854
43	B.C. Northport/PM-10	.0200		.0900		.0100				.1600		
43	B.C. Northport/PM-10	.0200		.0900		.0100				.1600		
49	Paparich/PM-10	.0156	.0132		.1384	.0055	.0246	.0188	.0161	.1554	.0001	.2815
58	B.C. Northport/TSP	.0100		.1100		.0100				.2900		
58	B.C. Northport/TSP	.0100		.1100		.0100				.2900		
DATE: 11-Sep-1993												
15	Paparich/SPM-10	.0020	0.0000		.0099	.0017	.0005	.0074	.0047	.0143	0.0000	.1697
DATE: 12-Sep-1993												
12	Paparich/SPM-10	.0030	0.0000		.0231	.0025	0.0000	.0047	.0151	.0238	.0003	.0768
DATE: 13-Sep-1993												
22	Paparich/SPM-10	.0038	.0066		.0296	.0040	.0021	.0080	.0066	.0959	.0004	.1968
DATE: 14-Sep-1993												
7	Paparich/SPM-10	.0258	.0264		.1671	.0119	.0010	.0034	.0445	.1306	.0016	.0421
DATE: 15-Sep-1993												
2	Paparich/SPM-10	.0156	.0145		.0679	.0030	.0032	.0013	.0161	.0581	.0004	.0312
DATE: 16-Sep-1993												
6	B.C. Northport/PM-10	.0100		.0600		.0100				.0700		
6	B.C. Northport/PM-10	.0100		.0600		.0100				.0700		
6	China Bend/PM-10	.0079	0.0000		.0546	.0035	.0255	.0011	.0052	.0466	.0009	.0262
6	Paparich/PM-10	.0219	.0183		.1296	.0063	.0214	.0015	.0225	.1181	.0011	.0241
8	Kettle Falls/PM-10	.0036	0.0000		.0245	.0009	.0166	.0037	.0058	.0241	.0001	.0342
8	Paparich/TSP		.0183	.1366	.1287	.0060	.0295	.0032	.0309	.2237	.0008	.0396
9	B.C. Northport/TSP	.0200		.0900		.0100				.1800		
9	B.C. Northport/TSP	.0200		.0900		.0100				.1800		
10	Paparich/SPM-10	.0189	.0188		.1063	.0053	.0054	.0016	.0294	.1018	.0007	.0190
DATE: 17-Sep-1993												

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 8-Sep-1993																						
Paparich/SPM-10	.0119	.0082	0.0000	4.3319	4.2205	.0002	.0006	.3615	.3343	0.0000	.2479	.2278	0.0000	.8813	0.0000	.0012	1.0851	.0042	.0030	.0189	.0019	.001
DATE: 9-Sep-1993																						
Paparich/SPM-10	.0210	.0109	0.0000	1.9082	1.8817	0.0000	.0008	.2714	.2133	0.0000	.1465	.1162	0.0000	.8413	0.0000	.0086	.9369	.0007	.0021	.0149	0.0000	.001
DATE: 10-Sep-1993																						
China Bend/PM-10	.0142	.0053	0.0000	.4988	.4813	.0004	.0010	.3124	.3461	.4183	.1236	.1384	.0005	.6259	0.0000	0.0000	.3532	.0012	.0011	.0104	.0074	.000
Paparich/SPM-10	.0129	.0078	0.0000	4.6357	4.5072	0.0000	.0011	.4462	.4221	0.0000	.2745	.2536	0.0000	.8394	0.0000	.0073	1.0344	0.0000	.0034	.0228	0.0000	.002
Kettle Falls/PM-10	.0099	.0132	0.0000	.9746	.9378	.0003	.0017	.5783	.6377	.7099	.3858	.3990	.0018	.6796	.0011	0.0000	.7281	.0075	.0032	.0268	.0086	.001
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Paparich/PM-10	.0120	.0077	0.0000	5.4997	5.3005	0.0000	.0005	.3985	.4857	.4040	.2955	.3127	.0004	.6069	0.0000	0.0000	.4982	.0023	.0041	.0191	.0100	.001
B.C. Northport/TSP																						
B.C. Northport/TSP																						
DATE: 11-Sep-1993																						
Paparich/SPM-10	.0110	.0045	0.0000	1.6698	1.6479	0.0000	.0000	.1927	.1361	0.0000	.1168	.0840	0.0000	.7660	.0019	.0116	.6670	.0017	.0012	.0112	0.0000	0.000
DATE: 12-Sep-1993																						
Paparich/SPM-10	.0096	.0026	0.0000	1.4386	1.4231	.0003	.0005	.0938	.0239	0.0000	.0799	.0472	0.0000	.6856	0.0000	0.0000	.4321	.0008	.0009	.0051	0.0000	.000
DATE: 13-Sep-1993																						
Paparich/SPM-10	.0115	.0046	0.0000	3.1911	3.1381	.0006	.0002	.2205	.1687	0.0000	.1662	.1344	0.0000	.8198	0.0000	.0058	.7358	0.0000	.0019	.0127	0.0000	0.000
DATE: 14-Sep-1993																						
Paparich/SPM-10	.0121	.0017	0.0000	.4131	.4158	0.0000	.0000	.0559	0.0000	0.0000	.0446	.0081	0.0000	.7827	0.0000	.0049	.3010	0.0000	.0003	.0030	0.0000	0.000
DATE: 15-Sep-1993																						
Paparich/SPM-10	.0298	.0054	0.0000	.2522	.2577	0.0000	.0005	.0259	0.0000	0.0000	.0364	.0002	0.0000	.8863	0.0000	.0108	.5181	0.0000	.0001	.0015	0.0000	0.000
DATE: 16-Sep-1993																						
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
China Bend/PM-10	.0105	.0016	0.0000	.2093	.1995	0.0000	.0007	.0319	.0619	.2679	.0393	.0540	0.0000	.6097	.0029	.0055	.2275	0.0000	.0003	.0009	.0160	0.000
Paparich/PM-10	.0096	.0012	0.0000	.3178	.3057	.0012	.0006	.0400	.0662	.2397	.0423	.0548	.0001	.6000	0.0000	.0011	.1787	.0035	.0005	.0012	.0063	0.000
Kettle Falls/PM-10	.0051	.0025	0.0000	.2535	.2446	.0008	0.0000	.0497	.0679	.2294	.0592	.0684	.0001	.5759	0.0000	.0041	.1844	.0011	.0007	.0013	.0039	0.000
Paparich/TSP	.0085	.0013	0.0000	.2962	.2841	0.0000	.0019	.0520	.0887	.3324	.0444	.0585	.0009	.5455	.0032	.0068	.1723	.0053	.0006	.0013	.0091	0.000
B.C. Northport/TSP																						
B.C. Northport/TSP																						
Paparich/SPM-10	.0131	.0013	.0000	.2987	.3020	.0006	.0003	.0250	0.0000	0.0000	.0462	.0126	0.0000	.7081	0.0000	.0053	.4027	0.0000	.0001	.0013	0.0000	.001
DATE: 17-Sep-1993																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 17-Sep-1993												
15	Paparich/SPM-10	.0228	.0243		.1915	.0104	.0019	.0041	.0346	.1858	.0015	.0675
DATE: 18-Sep-1993												
15	Paparich/SPM-10	.0209	.0192		.1791	.0103	.0018	.0062	.0374	.1610	.0011	.1574
DATE: 19-Sep-1993												
14	Paparich/SPM-10	.0013	0.0000		.0037	.0005	0.0000	.0068	.0052	.0077	.0070	.1686
DATE: 20-Sep-1993												
9	Paparich/SPM-10	.0040	0.0000		.0619	.0033	.0006	.0040	.0019	.0452	0.0000	.0711
DATE: 21-Sep-1993												
3	Paparich/SPM-10	.0145	.0120		.0777	.0043	0.0000	.0012	.0222	.1056	0.0000	.0073
DATE: 22-Sep-1993												
	Onion Ck/PPM-10											
	Waneta/PPM-10											
4	B.C. Northport/PM-10	.0100		.0200		.0100				.0500		
4	B.C. Northport/PM-10	.0100		.0200		.0100				.0500		
8	China Bend/PM-10	.0023	.0080		.0042	.0002	.0168	.0021	.0019	.0107	0.0000	.0224
9	Paparich/PM-10	.0065	0.0000		.0426	.0017	.0279	.0027	.0044	.0495	.0004	.0388
10	Paparich/SPM-10	.0056	.0090		.0349	.0023	.0036	.0020	.0090	.0413	0.0000	.0369
12	Worthern/PPM-10											
13	Paparich/TSP		0.0000	.0412	.0369	.0022	.0378	.0029	.0036	.0579	.0004	.0519
15	B.C. Northport/TSP	.0100		.0300		.0100				.0700		
15	B.C. Northport/TSP	.0100		.0300		.0100				.0700		
16	Kettle Falls/PM-10	.0017	0.0000		.0014	.0006	.0325	.0081	.0092	.0149	0.0000	.1105
37	Trail PW/PPM-10											
DATE: 23-Sep-1993												
17	Paparich/SPM-10	.0251	.0264		.1728	.0122	.0001	.0024	.0388	.1307	.0010	.0167
DATE: 24-Sep-1993												
15	Paparich/SPM-10	.0133	.0143		.0398	.0016	.0001	.0057	.0303	.0369	.0002	.0930
DATE: 25-Sep-1993												
14	Paparich/SPM-10	.0146	.0188		.1676	.0081	.0002	.0034	.0208	.1098	.0005	.0554
DATE: 26-Sep-1993												
12	Paparich/SPM-10	.0296	.0269		.2654	.0127	.0004	.0031	.0322	.1187	.0003	.0450
DATE: 27-Sep-1993												
15	Paparich/SPM-10	.0243	.0292		.2368	.0107	.0004	.0048	.0270	.2438	.0011	.0638

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 17-Sep-1993																						
Paparich/SPM-10	.0081	.0051	0.0000	1.2338	1.2246	0.0000	.0011	.0997	.0202	0.0000	.0811	.0450	0.0000	.7426	0.0000	0.0000	.3490	.0005	.0008	.0046	0.0000	.000
DATE: 18-Sep-1993																						
Paparich/SPM-10	.0165	.0136	0.0000	2.3501	2.3224	0.0000	.0027	.3170	.2596	0.0000	.1361	.1005	0.0000	.8491	0.0000	.0107	.6812	0.0000	.0017	.0085	0.0000	0.000
DATE: 19-Sep-1993																						
Paparich/SPM-10	.0176	.0035	.0000	1.1489	1.1433	0.0000	.0004	.2017	.1255	0.0000	.1145	.0748	0.0000	.8502	0.0000	.0027	.6747	.0007	.0012	.0112	0.0000	.000
DATE: 20-Sep-1993																						
Paparich/SPM-10	.0081	.0018	.0001	.3568	.3631	.0012	.0008	.1016	.0089	0.0000	.0610	.0206	0.0000	.7452	0.0000	.0016	.4475	0.0000	.0004	.0057	0.0000	.001
DATE: 21-Sep-1993																						
Paparich/SPM-10	.0131	.0013	.0001	.2683	.2768	0.0000	.0017	.0247	0.0000	0.0000	.0320	0.0000	0.0000	.8526	0.0000	.0016	.3297	0.0000	0.0000	.0007	0.0000	0.000
DATE: 22-Sep-1993																						
Onion Ck/PPM-10																						
Waneta/PPM-10																						
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
China Bend/PM-10	.0072	.0026	0.0000	.2566	.2531	0.0000	.0006	.0592	.0006	0.0000	.0449	.0244	0.0000	.5352	0.0000	.0100	.3505	.0013	.0002	.0012	0.0000	.000
Paparich/PM-10	.0138	.0033	0.0000	.2863	.2722	.0020	.0005	.0412	.0662	.3770	.0463	.0616	.0007	.6854	0.0000	.0009	.2146	.0034	.0007	.0017	.0181	.000
Paparich/SPM-10	.0096	.0016	0.0000	.3189	.3253	0.0000	0.0000	.0463	0.0000	0.0000	.0439	.0045	0.0000	.7066	0.0000	.0026	.2211	.0010	.0006	.0024	0.0000	.000
Worthern/PPM-10																						
Paparich/TSP	.0071	.0015	0.0000	.4167	.4031	.0004	.0012	.0656	.0948	.2902	.0597	.0728	.0012	.5698	0.0000	.0007	.1645	.0018	.0006	.0025	0.0000	0.000
B.C. Northport/TSP																						
B.C. Northport/TSP																						
Kettle Falls/PM-10	.0071	.0052	0.0000	.4883	.4817	.0004	.0008	.1518	.1099	0.0000	.1199	.0983	0.0000	.6710	0.0000	.0111	.6754	.0048	.0013	.0058	0.0000	.001
Trail PW/PPM-10																						
DATE: 23-Sep-1993																						
Paparich/SPM-10	.0051	.0016	.0000	.3036	.3109	0.0000	.0007	.0343	0.0000	0.0000	.0350	0.0000	0.0000	.6290	.0024	.0005	.1585	.0030	.0001	.0014	.0002	0.000
DATE: 24-Sep-1993																						
Paparich/SPM-10	.0136	.0061	.0001	.5851	.5904	0.0000	.0004	.1275	.0306	0.0000	.0813	.0400	0.0000	.7687	0.0000	.0005	.4390	.0010	.0007	.0073	0.0000	.001
DATE: 25-Sep-1993																						
Paparich/SPM-10	.0081	.0023	.0001	.9915	.9928	0.0000	0.0000	.0818	0.0000	0.0000	.0710	.0286	0.0000	.8357	0.0000	.0067	.2917	0.0000	.0006	.0047	0.0000	.000
DATE: 26-Sep-1993																						
Paparich/SPM-10	.0111	.0019	.0001	.7416	.7486	0.0000	.0007	.0650	0.0000	0.0000	.0597	.0120	0.0000	.8094	0.0000	0.0000	.3934	.0004	.0004	.0037	.0002	.000
DATE: 27-Sep-1993																						
Paparich/SPM-10	.0045	.0024	.0001	1.1402	1.1413	0.0000	.0002	.0959	.0005	0.0000	.0757	.0317	0.0000	.7150	0.0000	.0052	.2584	0.0000	.0007	.0046	.0037	0.000

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 28-Sep-1993												
14	China Bend/PM-10	.0481	.0399		.3343	.0186	.0132	.0036	.0499	.4193	.0018	.0514
21	Paparich/SPM-10	.0620	.0688		.4800	.0269	.0082	.0081	.0814	.7874	.0026	.1115
22	Paparich/PM-10	.0691	.0706		.5135	.0282	.0224	.0069	.0893	.8758	.0031	.1092
25	Trail PW/PPM-10	.0679	.0290	.7412	.6344	.0400	.0209	.0170	.1196	1.6682	.0013	.0874
25	B.C. Northport/PM-10	.0600		.4800		.0200				.8700		
25	B.C. Northport/PM-10	.0600		.4800		.0200				.8700		
28	Kettle Falls/PM-10	.0313	.0159		.1675	.0086	.0256	.0139	.0363	.1779	.0013	.1538
28	Paparich/TSP		.0649	.5692	.5584	.0291	.0476	.0104	.0804	1.1176	.0018	.1260
36	Onion Ck/PPM-10	.0476		.0773		.0048	.0152	.0223	0.0000	.1079		
37	Worthern/PPM-10	.0896	.0929	.7968	.6753	.0397	.0087	.0146	.1196	1.4921	.0020	.0801
48	Waneta/PPM-10	.1164	.1578	1.0363	.9052	.0474	.0100	.0111	.1811	1.8764	.0023	.0877
58	B.C. Northport/TSP	.0700		.5300		.0300				1.2000		
58	B.C. Northport/TSP	.0700		.5300		.0300				1.2000		
DATE: 29-Sep-1993												
26	Paparich/SPM-10	.0344	.0270		.2324	.0125	.0023	.0115	.0341	.3360	.0005	.2103
DATE: 30-Sep-1993												
17	Paparich/SPM-10	.0038	.0069		.0241	.0105	.0007	.0126	.0024	.0563	.0004	.2368
DATE: 1-Oct-1993												
19	Paparich/SPM-10											
DATE: 2-Oct-1993												
32	Paparich/SPM-10											
DATE: 3-Oct-1993												
33	Paparich/SPM-10											
DATE: 4-Oct-1993												
	Onion Ck/PPM-10											
	Waneta/PPM-10											
26	Trail PW/PPM-10											
27	B.C. Northport/PM-10	.0200		.1500		.0100				.1400		
27	B.C. Northport/PM-10	.0200		.1500		.0100				.1400		
31	Paparich/SPM-10											
38	B.C. Northport/TSP	.0200		.1500		.0100				.2000		
38	B.C. Northport/TSP	.0200		.1500		.0100				.2000		
51	Worthern/PPM-10											
DATE: 5-Oct-1993												
53	Paparich/SPM-10											
DATE: 6-Oct-1993												

****

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 28-Sep-1993																						
China Bend/PM-10	.0077	.0035	0.0000	.3810	.3675	0.0000	.0030	.0805	.1054	.3377	.0596	.0739	.0012	.6562	.0038	0.0000	.2004	.0043	.0007	.0029	.0187	0.000
Paparich/SPM-10	.0110	.0090	.0001	1.3729	1.3710	.0009	.0008	.1432	.0529	0.0000	.0955	.0526	.0003	.7641	.0026	.0148	.5011	.0038	.0012	.0063	.0119	.001
Paparich/PM-10	.0103	.0043	0.0000	1.3659	1.3332	0.0000	0.0000	.1716	.1205	0.0000	.0988	.0826	0.0000	.7952	0.0000	.0060	.8227	.0082	.0013	.0073	0.0000	.000
Trail PW/PPM-10	.0620	.0114	.0009	1.5953	1.6447	0.0000	0.0000	.2632	0.0000	0.0000	.2260	0.0000	0.0000	5.7068	.0026	.0418	2.3076	0.0000	.0003	.0101	0.0000	.003
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Kettle Falls/PM-10	.0094	.0086	0.0000	.6127	.5914	.0012	.0012	.2461	.2814	.3981	.1582	.1694	.0004	.6746	.0005	0.0000	.3451	.0037	.0021	.0078	.0153	0.000
Paparich/TSP	.0073	.0054	0.0000	1.7071	1.6591	0.0000	.0015	.1931	.2308	.2972	.1166	.1308	.0015	.5593	0.0000	.0096	.2619	.0073	.0020	.0073	.0227	0.000
Onion Ck/PPM-10																						
Worthern/PPM-10	.0366	.0107	.0006	1.7605	1.8112	0.0000	.0056	.1868	0.0000	0.0000	.2357	0.0000	0.0000	5.7212	0.0000	0.0000	4.7283	0.0000	.0005	.0081	0.0000	0.000
Waneta/PPM-10	.1395	.0123	.0006	1.5111	1.5680	0.0000	.0048	.2369	0.0000	0.0000	.2276	0.0000	0.0000	6.0544	0.0000	.0333	3.0595	.0024	.0003	.0086	0.0000	.005
B.C. Northport/TSP																						
B.C. Northport/TSP																						
DATE: 29-Sep-1993																						
Paparich/SPM-10	.0064	.0060	.0000	2.4802	2.4497	.0017	.0004	.2330	.1612	0.0000	.1638	.1287	0.0000	.7553	.0037	.0059	.5401	0.0000	.0019	.0112	0.0000	.000
DATE: 30-Sep-1993																						
Paparich/SPM-10	.0160	.0063	0.0000	2.8612	2.8119	.0035	.0001	.2561	.1995	0.0000	.1723	.1409	0.0000	.8323	.0080	.0086	.5384	0.0000	.0023	.0127	0.0000	.001
DATE: 1-Oct-1993																						
Paparich/SPM-10																						
DATE: 2-Oct-1993																						
Paparich/SPM-10																						
DATE: 3-Oct-1993																						
Paparich/SPM-10																						
DATE: 4-Oct-1993																						
Onion Ck/PPM-10																						
Waneta/PPM-10																						
Trail PW/PPM-10																						
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Paparich/SPM-10																						
B.C. Northport/TSP																						
B.C. Northport/TSP																						
Worthern/PPM-10																						
DATE: 5-Oct-1993																						
Paparich/SPM-10																						
DATE: 6-Oct-1993																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 6-Oct-1993												
22	Paparich/SPM-10											
DATE: 7-Oct-1993												
7	Paparich/SPM-10											
DATE: 8-Oct-1993												
9	Paparich/SPM-10											
DATE: 9-Oct-1993												
12	Paparich/SPM-10											
DATE: 10-Oct-1993												
13	B.C. Northport/PM-10	.0400		.3200		.0100				.2600		
13	B.C. Northport/PM-10	.0400		.3200		.0100				.2600		
14	Paparich/SPM-10											
23	B.C. Northport/TSP	.0400		.3800		.0200				.3800		
23	B.C. Northport/TSP	.0400		.3800		.0200				.3800		
DATE: 11-Oct-1993												
21	Paparich/SPM-10											
DATE: 12-Oct-1993												
19	Paparich/SPM-10											
DATE: 13-Oct-1993												
15	Paparich/SPM-10											
DATE: 14-Oct-1993												
12	Paparich/SPM-10											
DATE: 15-Oct-1993												
10	Paparich/SPM-10											
DATE: 16-Oct-1993												
	Trail PW/PPM-10											
	Waneta/PPM-10											
	Worthern/PPM-10											
9	Kettle Falls/PM-10	.0091	.0103		.0477	.0009	.0183	.0032	.0172	.0419	0.0000	.0112
10	B.C. Northport/PM-10	.0100		.2100		.0100				.1700		
10	B.C. Northport/PM-10	.0100		.2100		.0100				.1700		
12	Paparich/PM-10	.0311	.0277		.2934	.0143	.0267	.0016	.0358	.2218	.0022	.0071

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 6-Oct-1993																						
Paparich/SPM-10																						
DATE: 7-Oct-1993																						
Paparich/SPM-10																						
DATE: 8-Oct-1993																						
Paparich/SPM-10																						
DATE: 9-Oct-1993																						
Paparich/SPM-10																						
DATE: 10-Oct-1993																						
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Paparich/SPM-10																						
B.C. Northport/TSP																						
B.C. Northport/TSP																						
DATE: 11-Oct-1993																						
Paparich/SPM-10																						
DATE: 12-Oct-1993																						
Paparich/SPM-10																						
DATE: 13-Oct-1993																						
Paparich/SPM-10																						
DATE: 14-Oct-1993																						
Paparich/SPM-10																						
DATE: 15-Oct-1993																						
Paparich/SPM-10																						
DATE: 16-Oct-1993																						
Trail PW/PPM-10																						
Waneta/PPM-10																						
Worthern/PPM-10																						
Kettle Falls/PM-10	.0038	.0014	0.0000	.2225	.2258	0.0000	.0009	.0311	0.0000	0.0000	.0468	.0178	0.0000	.5734	0.0000	.0036	.3498	.0021	.0004	.0008	0.0000	0.000
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Paparich/PM-10	.0078	.0009	0.0000	.1983	.2034	0.0000	0.0000	.0284	0.0000	0.0000	.0392	0.0000	0.0000	.6503	0.0000	.0096	.6116	.0043	.0000	.0010	0.0000	0.000

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 16-Oct-1993												
13	B.C. Northport/TSP	.0300		.2500		.0100				.2300		
13	B.C. Northport/TSP	.0300		.2500		.0100				.2300		
14	Paparich/SPM-10											
15	China Bend/PM-10	.0384	.0289		.2189	.0118	.0403	.0010	.0468	.1346	.0004	.0210
DATE: 17-Oct-1993												
10	Paparich/SPM-10											
DATE: 18-Oct-1993												
10	Paparich/SPM-10											
DATE: 19-Oct-1993												
5	Paparich/SPM-10											
DATE: 20-Oct-1993												
15	Paparich/SPM-10											
DATE: 21-Oct-1993												
17	Paparich/SPM-10											
DATE: 22-Oct-1993												
	Onion Ck/PPM-10											
19	Paparich/SPM-10											
20	China Bend/PM-10	.0140	.0012		.0598	.0029	.0326	.0032	.0100	.0707	.0005	.0410
22	Paparich/PM-10	.0183	.0140		.0622	.0037	.0248	.0063	.0118	.0896	.0005	.0916
24	B.C. Northport/PM-10	.0400		.2500		.0100				.3900		
24	B.C. Northport/PM-10	.0400		.2500		.0100				.3900		
30	Kettle Falls/PM-10	.0111	.0018		.0340	.0029	.0176	.0128	.0068	.0517	.0006	.1233
33	B.C. Northport/TSP	.0400		.3100		.0100				.6300		
33	B.C. Northport/TSP	.0400		.3100		.0100				.6300		
35	Waneta/PPM-10	.0757	.0802	.3321	.2820	.0175	.0029	.0084	.0677	.8467	.0051	.0436
36	Trail PW/PPM-10	.3991	.3709	.5064	.4729	.0209	.0094	.0979	.2670	.9463	.0155	.0732
37	Worthern/PPM-10											
DATE: 23-Oct-1993												
21	Paparich/SPM-10											
DATE: 24-Oct-1993												
9	Paparich/SPM-10											
DATE: 25-Oct-1993												
10	Paparich/SPM-10											
DATE: 26-Oct-1993												

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 16-Oct-1993																						
B.C. Northport/TSP																						
B.C. Northport/TSP																						
Paparich/SPM-10																						
China Bend/PM-10	.0058	.0022	0.0000	.1942	.1844	.0008	.0013	.0233	.0541	.3118	.0392	.0528	.0007	.6163	.0050	0.0000	.1641	.0067	.0003	.0004	.0133	0.000
DATE: 17-Oct-1993																						
Paparich/SPM-10																						
DATE: 18-Oct-1993																						
Paparich/SPM-10																						
DATE: 19-Oct-1993																						
Paparich/SPM-10																						
DATE: 20-Oct-1993																						
Paparich/SPM-10																						
DATE: 21-Oct-1993																						
Paparich/SPM-10																						
DATE: 22-Oct-1993																						
Onion Ck/PPM-10																						
Paparich/SPM-10																						
China Bend/PM-10	.0094	.0037	0.0000	.2695	.2592	0.0000	.0014	.1083	.1347	.3373	.0525	.0634	.0013	.5476	.0009	.0038	.1741	.0031	.0005	.0022	.0003	0.000
Paparich/PM-10	.0099	.0027	0.0000	.4934	.4593	.0004	0.0000	.0996	.1869	.7675	.0666	.1071	.0002	.5520	.0017	0.0000	.3784	.0052	.0011	.0045	.0010	0.000
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
Kettle Falls/PM-10	.0116	.0073	0.0000	.5108	.4736	.0004	.0016	.1659	.2536	.9465	.1257	.1607	.0002	.6003	.0014	0.0000	.4688	.0075	.0020	.0060	0.0000	.000
B.C. Northport/TSP																						
B.C. Northport/TSP																						
Waneta/PPM-10	.0689	.0340	.0006	1.4540	1.4899	0.0000	.0046	.1256	0.0000	0.0000	.1907	0.0000	0.0000	5.3044	0.0000	.0589	3.3212	.0013	.0010	.0060	.0140	.002
Trail PW/PPM-10	.0387	.0202	.0006	1.5468	1.5831	.0101	.0020	.2548	0.0000	0.0000	.2482	0.0000	0.0000	5.5152	0.0000	.0386	4.0407	0.0000	.0007	.0097	0.0000	.002
Worthern/PPM-10																						
DATE: 23-Oct-1993																						
Paparich/SPM-10																						
DATE: 24-Oct-1993																						
Paparich/SPM-10																						
DATE: 25-Oct-1993																						
Paparich/SPM-10																						
DATE: 26-Oct-1993																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 26-Oct-1993												
15	Paparich/SPM-10											
DATE: 27-Oct-1993												
15	Paparich/SPM-10											
DATE: 28-Oct-1993												
	Onion Ck/PPM-10											
	Trail PW/PPM-10											
12	Worthern/PPM-10	.0733	.0521	.2352	.2127	.0141	0.0000	.0048	.1150	.5452	.0037	.0201
16	China Bend/PM-10	.0135	.0082		.0694	.0037	.0096	.0030	.0195	.0680	.0003	.0491
17	Paparich/PM-10	.0346	.0173		.4162	.0131	.0160	.0041	.0339	.2424	.0007	.0598
17	Paparich/SPM-10											
20	Kettle Falls/PM-10	.0041	0.0000		.0134	.0011	.0206	.0112	.0024	.0281	.0003	.0862
24	B.C. Northport/PM-10	.0500		.4200		.0100				.2600		
24	B.C. Northport/PM-10	.0500		.4200		.0100				.2600		
35	B.C. Northport/TSP	.0400		.5100		.0200				.4200		
35	B.C. Northport/TSP	.0400		.5100		.0200				.4200		
36	Waneta/PPM-10	.0479	.0084	.4195	.3630	.0097	.0124	.0094	.0166	.5832	0.0000	.2322
DATE: 29-Oct-1993												
15	Paparich/SPM-10											
DATE: 30-Oct-1993												
17	Paparich/SPM-10											
DATE: 3-Nov-1993												
7	B.C. Northport/PM-10	.0100		.0200		.0100				.0100		
15	B.C. Northport/TSP	.0100		.0100		.0100				.0300		
DATE: 9-Nov-1993												
23	B.C. Northport/TSP	.0700		.3900		.0200				.2200		
32	B.C. Northport/PM-10	.0800		.3300		.0200				.2400		
DATE: 15-Nov-1993												
51	B.C. Northport/PM-10	.0100		.0100		.0100				.0100		
88	B.C. Northport/TSP	.0100		.0100		.0100				.0200		
DATE: 21-Nov-1993												
35	B.C. Northport/TSP	.0100		.0300		.0100				.0600		
37	B.C. Northport/PM-10	.0100		.0400		.0100				.0900		

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 26-Oct-1993																						
Paparich/SPM-10																						
DATE: 27-Oct-1993																						
Paparich/SPM-10																						
DATE: 28-Oct-1993																						
Onion Ck/PPM-10																						
Trail PW/PPM-10																						
Worthern/PPM-10	.1190	.0096	.0006	1.6381	1.6806	0.0000	.0090	.0969	0.0000	0.0000	.2161	0.0000	0.0000	5.9801	.0009	0.0000	3.5691	0.0000	0.0000	.0037	0.0000	.003
China Bend/PM-10	.0113	.0021	0.0000	.2838	.2573	.0004	.0009	.0910	.1737	.7598	.0483	.0912	.0001	.6136	0.0000	0.0000	.1739	.0014	.0007	.0015	.0023	0.000
Paparich/PM-10	.0087	.0023	0.0000	.7870	.7438	.0008	.0013	.0736	.1526	.5890	.0643	.0982	.0015	.5885	.0008	0.0000	.1973	.0085	.0010	.0027	.0133	.001
Paparich/SPM-10																						
Kettle Falls/PM-10	.0073	.0058	0.0000	.4403	.4139	.0004	0.0000	.1280	.1969	.6750	.1064	.1359	.0004	.5762	0.0000	.0070	.2320	.0094	.0015	.0039	.0000	0.000
B.C. Northport/PM-10																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
B.C. Northport/TSP																						
Waneta/PPM-10	.1132	.0629	.0009	1.7952	1.8596	0.0000	.0068	.3114	0.0000	0.0000	.2780	0.0000	0.0000	5.5134	0.0000	.0497	3.0312	.0137	.0032	.0137	0.0000	0.000
DATE: 29-Oct-1993																						
Paparich/SPM-10																						
DATE: 30-Oct-1993																						
Paparich/SPM-10																						
DATE: 3-Nov-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
DATE: 9-Nov-1993																						
B.C. Northport/TSP																						
B.C. Northport/PM-10																						
DATE: 15-Nov-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
DATE: 21-Nov-1993																						
B.C. Northport/TSP																						
B.C. Northport/PM-10																						

ug/m^3	Site/parameter	FURNACE AS	ICP AS	FURNACE Pb	ICP Pb	Cd	Cu	Mn	Sb	Zn	Ag	Al
DATE: 27-Nov-1993												
24	B.C. Northport/PM-10	.0400		1.1800		.0400				.5000		
33	B.C. Northport/TSP	.0400		1.4700		.0600				.7600		
DATE: 3-Dec-1993												
7	B.C. Northport/PM-10	.0400		.0100		.0100				.0500		
11	B.C. Northport/TSP	.0100		.0100		.0100				.0200		
DATE: 9-Dec-1993												
9	B.C. Northport/PM-10	.0200		.1400		.0100				.2100		
12	B.C. Northport/TSP	.0200		.2500		.0100				.1200		
DATE: 15-Dec-1993												
7	B.C. Northport/PM-10	.0700		.4000		.0100				.3200		
12	B.C. Northport/TSP	.0800		.4300		.0100				.3400		
DATE: 21-Dec-1993												
7	B.C. Northport/PM-10	.0100		.0600		.0100				.0900		
12	B.C. Northport/TSP	.0100		.0600		.0100				.1200		
DATE: 27-Dec-1993												
12	B.C. Northport/PM-10	.0300		.1500		.0100				.1100		
20	B.C. Northport/TSP	.0300		.1900		.0100				.2000		

SITE/PARAMETER	B_	Ba	Be	Ca	Ca-1	Co	Cr	Fe	Fe-1	K	Mg	Mg-1	Mo	Na	Ni	Se	Si	Sn	Sr	Ti	Tl	V_
DATE: 27-Nov-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
DATE: 3-Dec-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
DATE: 9-Dec-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
DATE: 15-Dec-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
DATE: 21-Dec-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						
DATE: 27-Dec-1993																						
B.C. Northport/PM-10																						
B.C. Northport/TSP																						